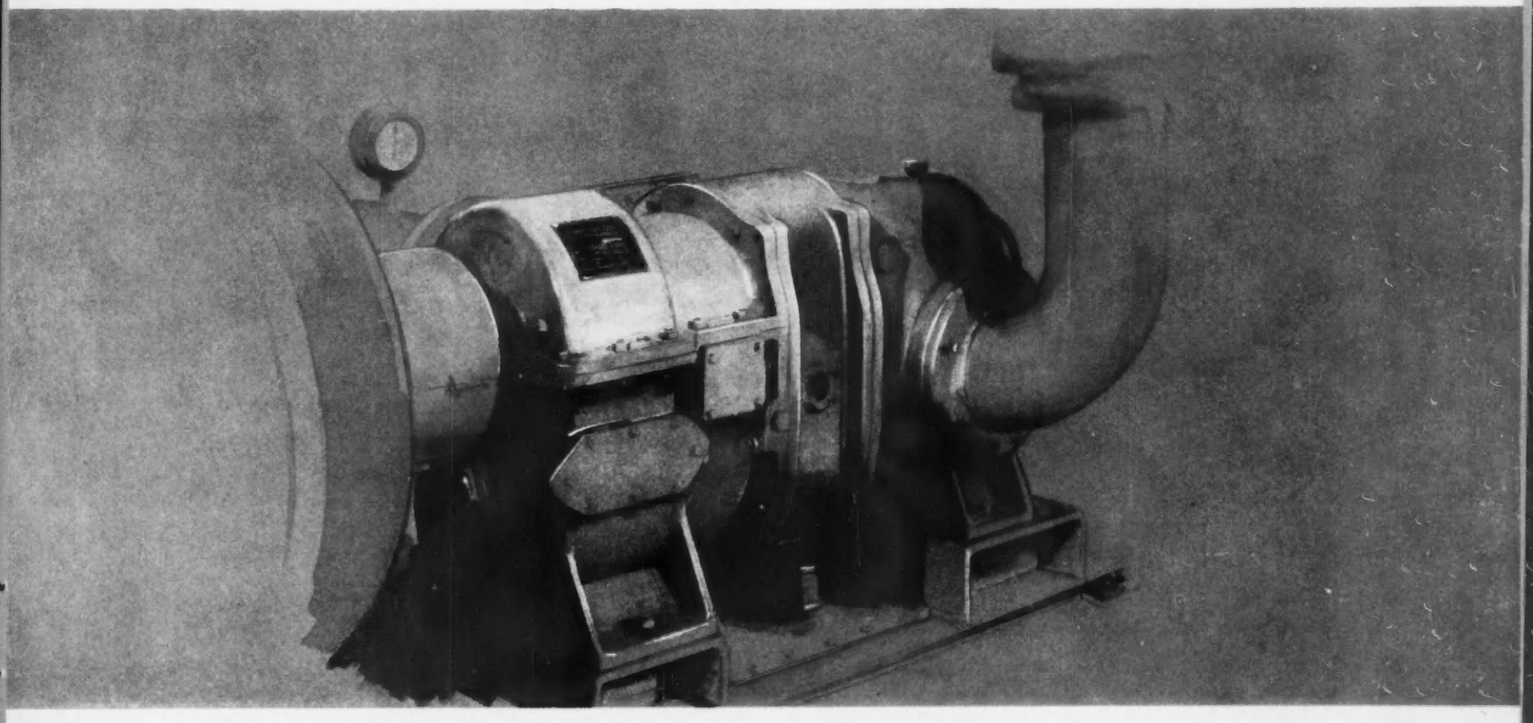
THE ENGINEER

MARCH 25, 1960 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS



Howden rotary-screw compressor, 1100 c.f.m., exhausting at 1/5 of an atmosphere at the AIRCRAFT RESEARCH ASSOCIATION, BEDFORD

Howden Compressors

For more than 12 years, Howden have been manufacturing and developing rotary-screw compressors. Howden compressors have many outstanding advantages, as follows:—

As rotary-screw compressors without any reciprocating parts they are fundamentally free from out-of-balance forces, with a large output in relation to their size. With their high speed and freedom from valves they give a pulseless delivery.

Accurate gearing maintains the rotors with a designed clearance; thus they never touch and are less affected by air-borne impurities. The rotors need no lubricant; the air or gas delivered is therefore oil-free, an advantage in certain industries and an economy in all.

Howden compressors are driven through Howden speed-increasing gearboxes from any suitable power source.

ECONOMICS OF THE COMPRESSOR

The simple mechanical construction reduces maintenance costs and increases availability. Cost of foundations is lower. Floor space occupied is smaller and receiver needed is smaller.

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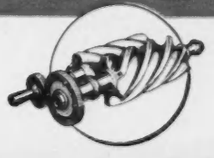
HOWDEN



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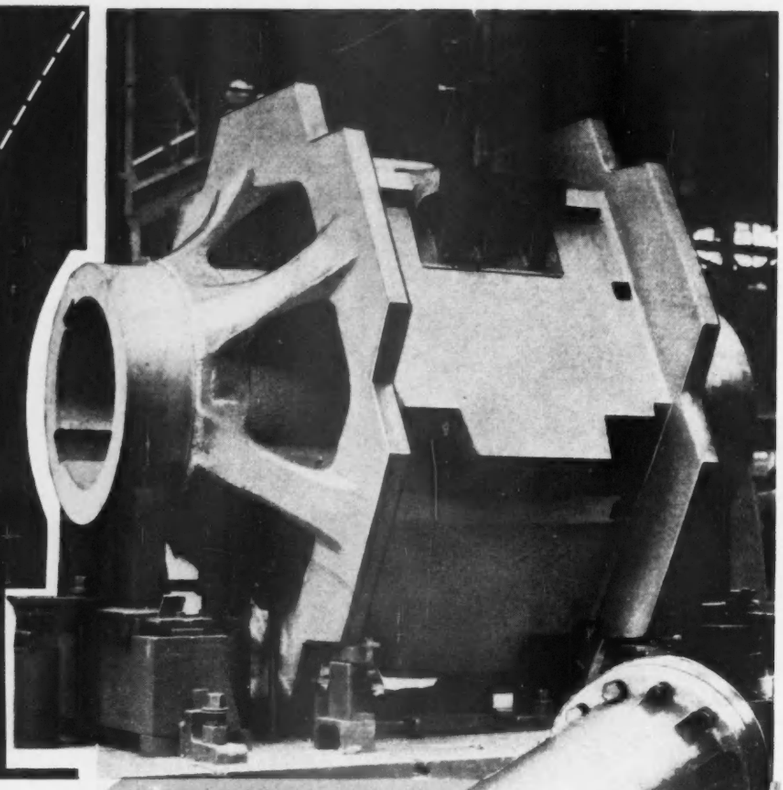
THINK OF STEEL CASTINGS FIRST



Top tumbler for tin dredging. Weight 17½ tons.

Best quality steel castings have many applications which offer certain economical advantages over other production methods. Before finalising your requirements ... **THINK OF CASTINGS FIRST** and consult Hadfields . . a name celebrated for Steels in **CARBON—LOW ALLOY—STAINLESS—MANGANESE—WEAR RESISTING—HEAT RESISTING STEELS.**

Tilting cylinder assembly. Weight 18 tons.

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Established 1856

No. 5435 MARCH 25, 1960 VOL. 209

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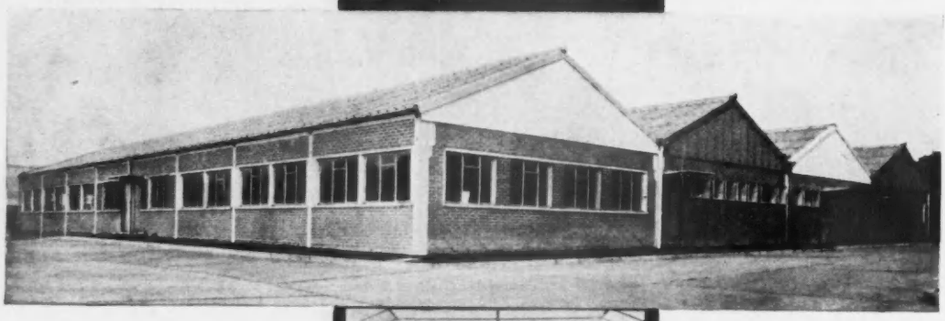

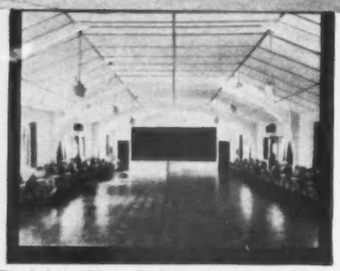

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TYLER TONBRIDGE

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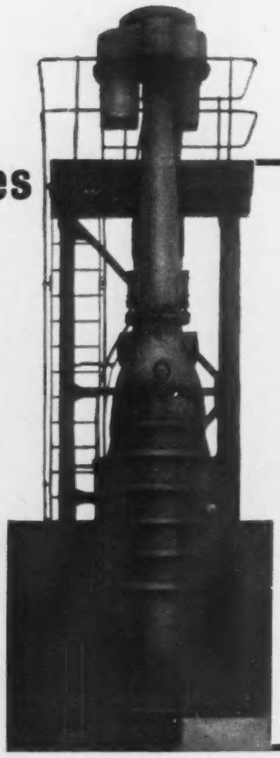
Northampton
relies on Bailey's valves



At the Northampton Power Station, Bailey valves control the water supply for the cooling system. Backed by more than a century's experience the company provides a standard range of high quality valves from 2 to 54 inch bore for pressures up to 150 p.s.i., for the control of oil, water, steam or gas. Advice is gladly given on all kinds of applications and a special Contracts Department is maintained to deal with valve schedules on large contracts anywhere in the world.

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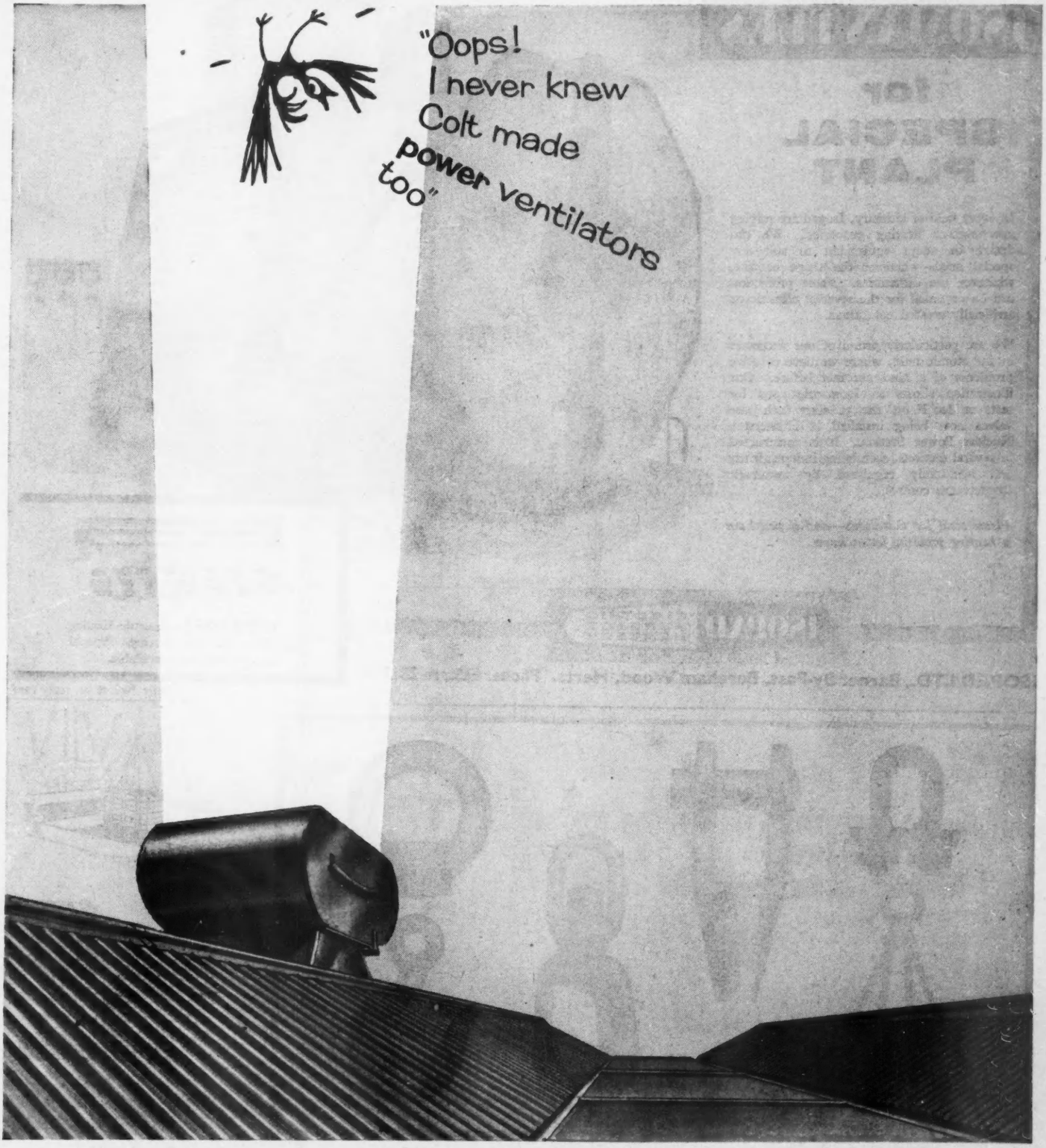

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In every field of industry, Isopad are solving new surface heating problems. We can design or adapt equipment to suit any special need—whatever the shape or size, whatever the difficulties. Frost protection can be provided for the severest climatic or artificially created conditions.

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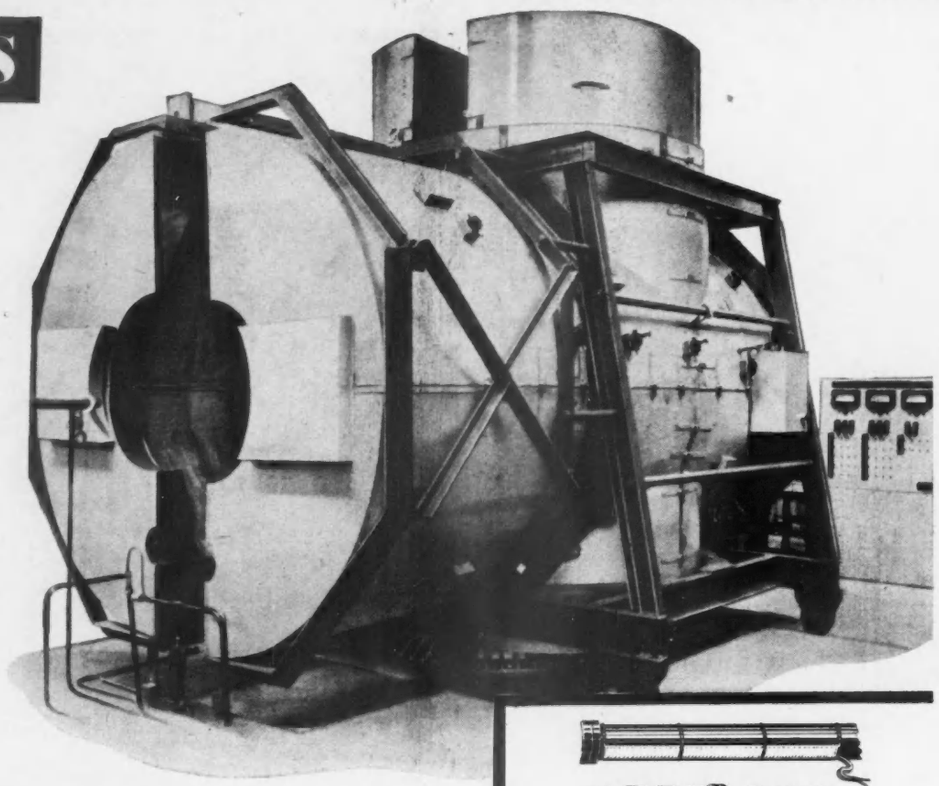

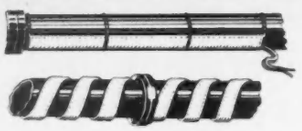

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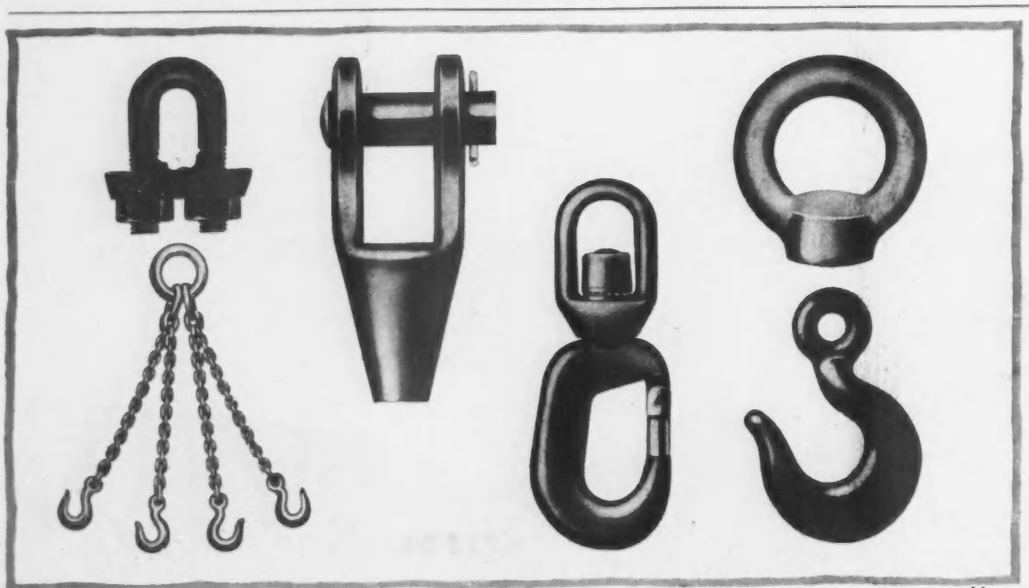

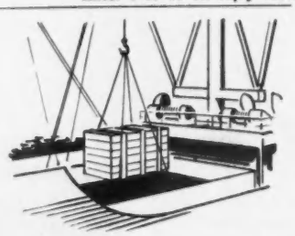

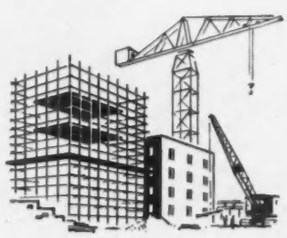

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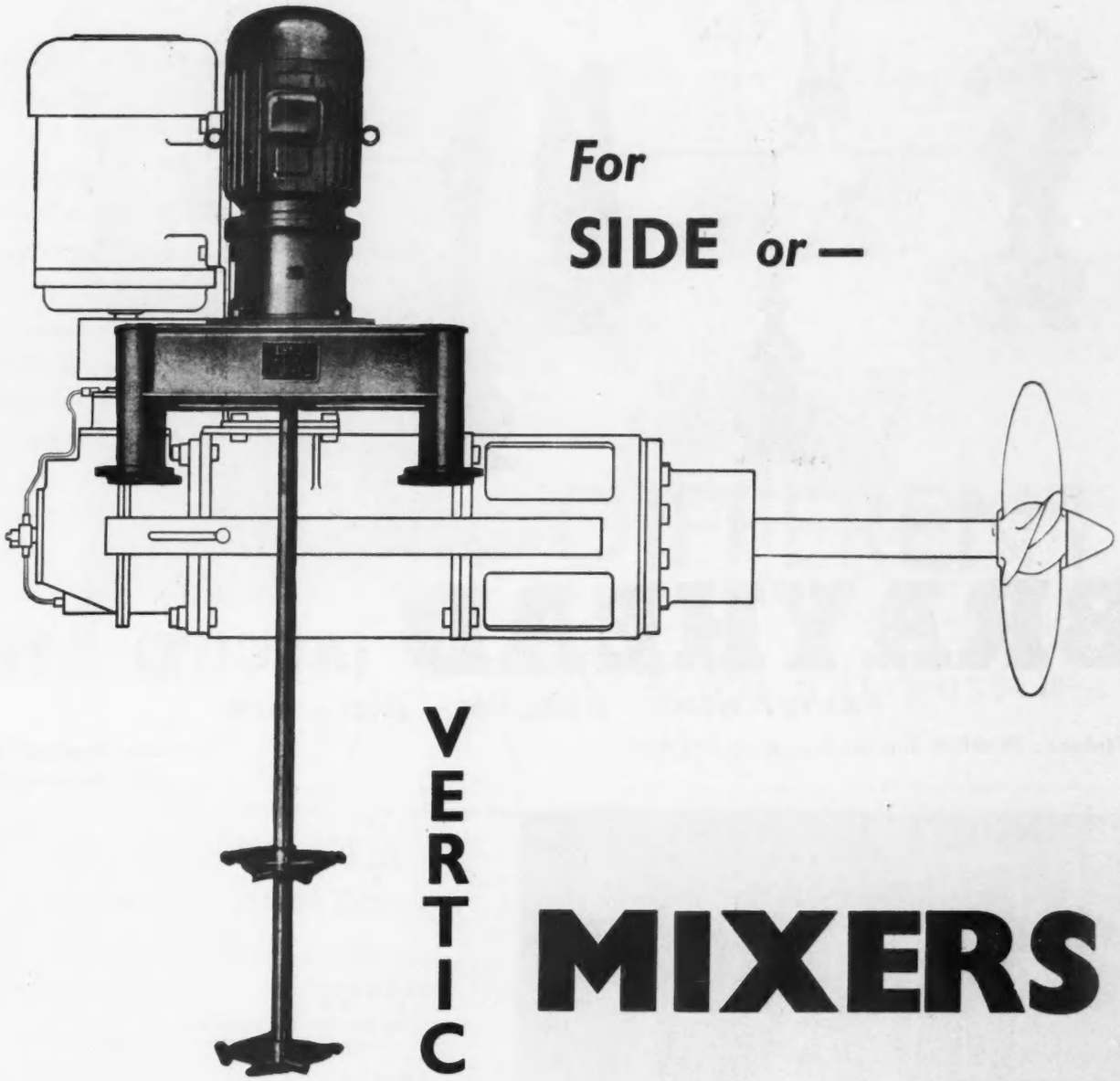

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SIDE *or —*

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MIXERS

Plenty manufacture a complete range of Mixers to suit all operating conditions. The vertical unit above is of the patent "Impelator" type, a scientific design, combining controlled circulation with intense mixing action. The Plenty patent, side entry, Propeller type mixer for large tanks is fitted with a mechanical seal which can be adjusted or renewed without draining the tank.

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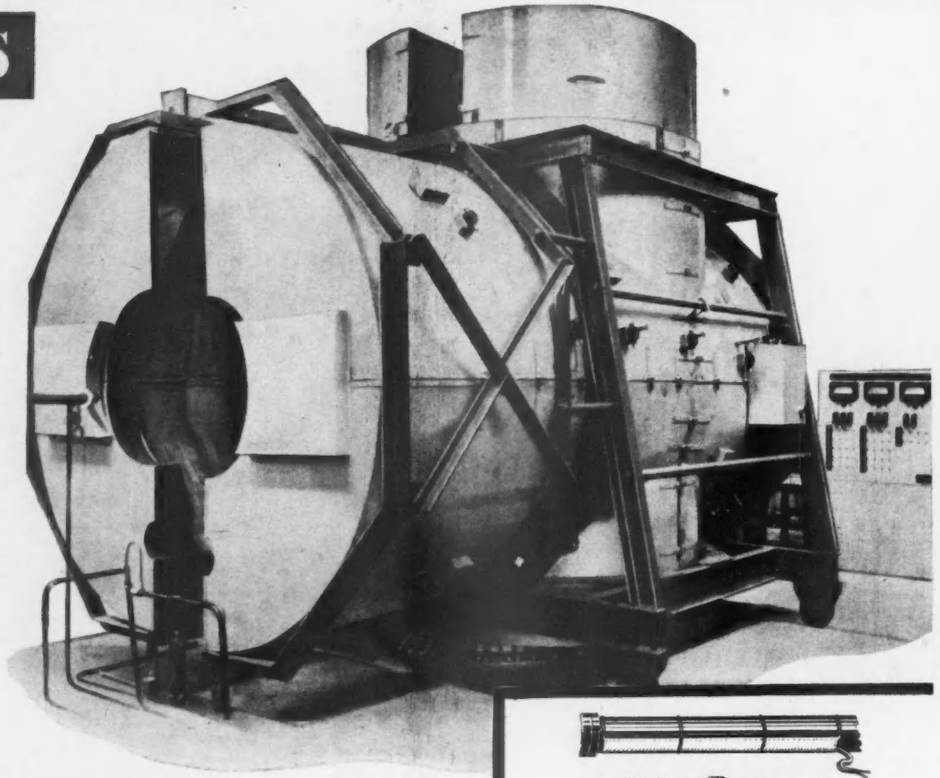

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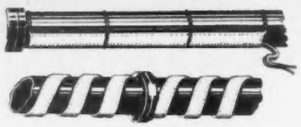

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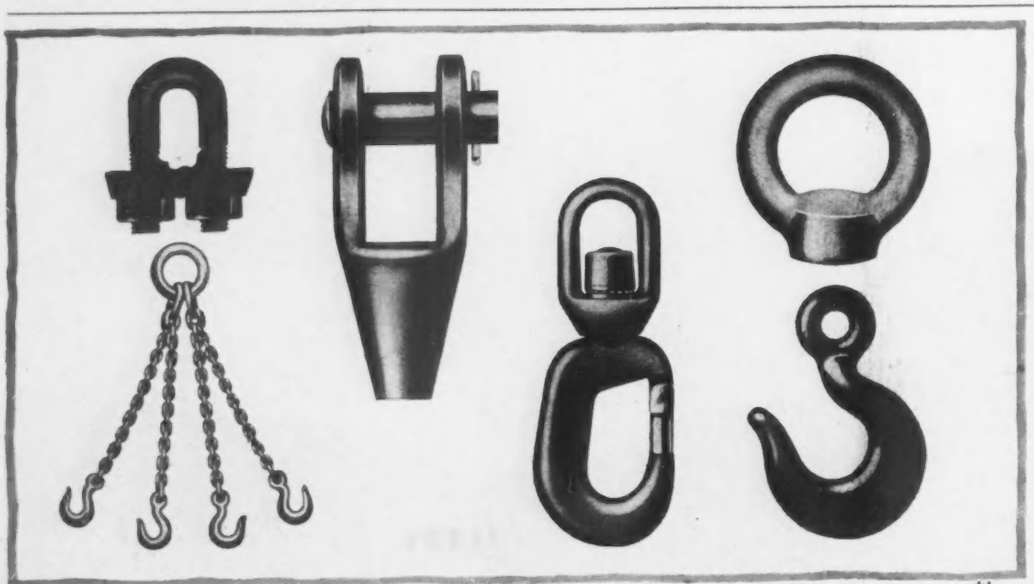

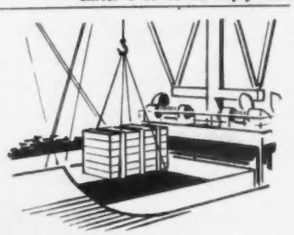

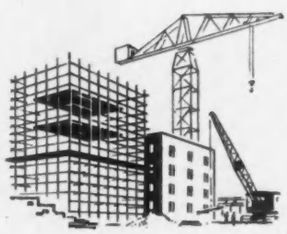

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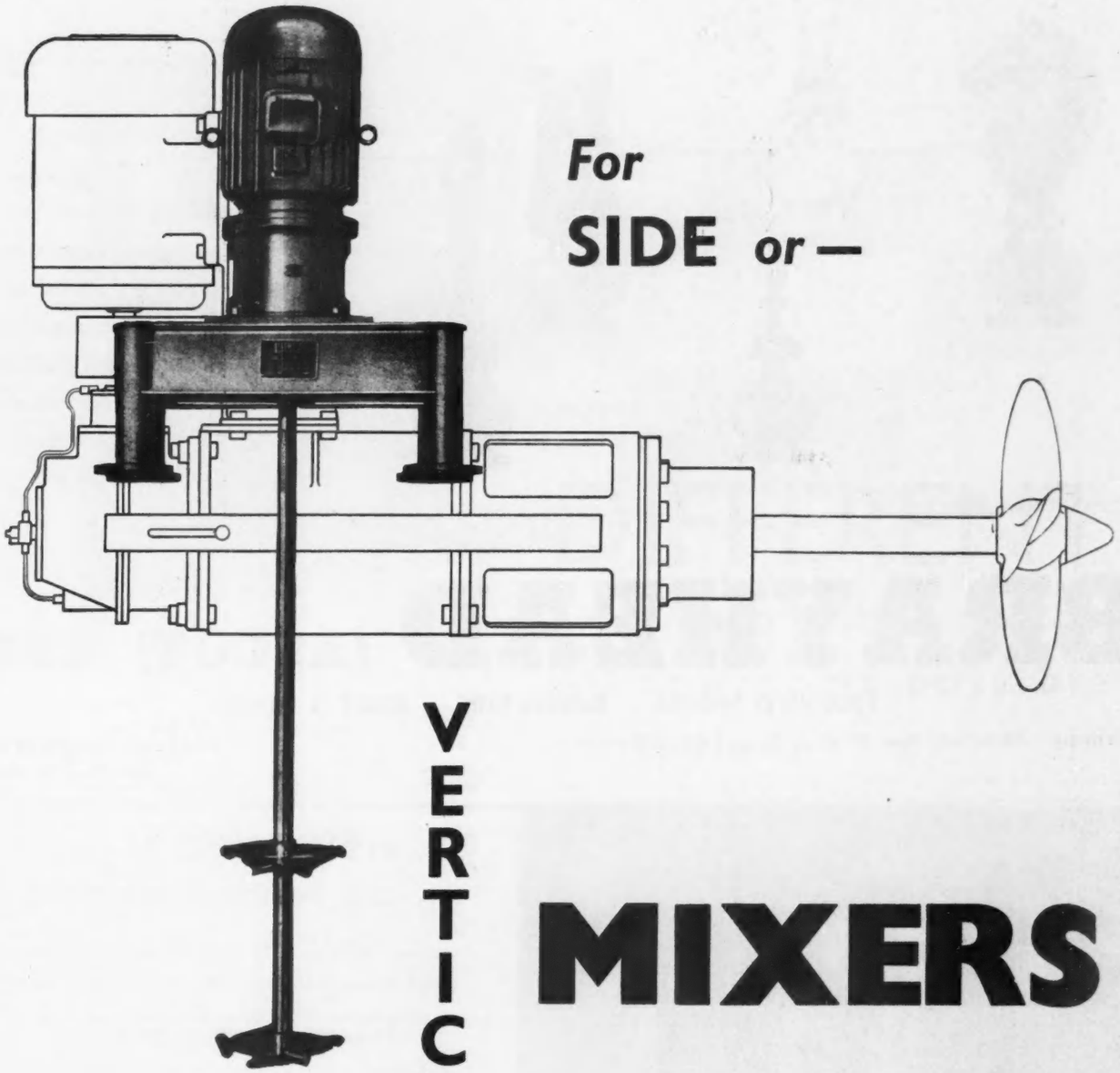

For

SIDE *or —*

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MIXERS

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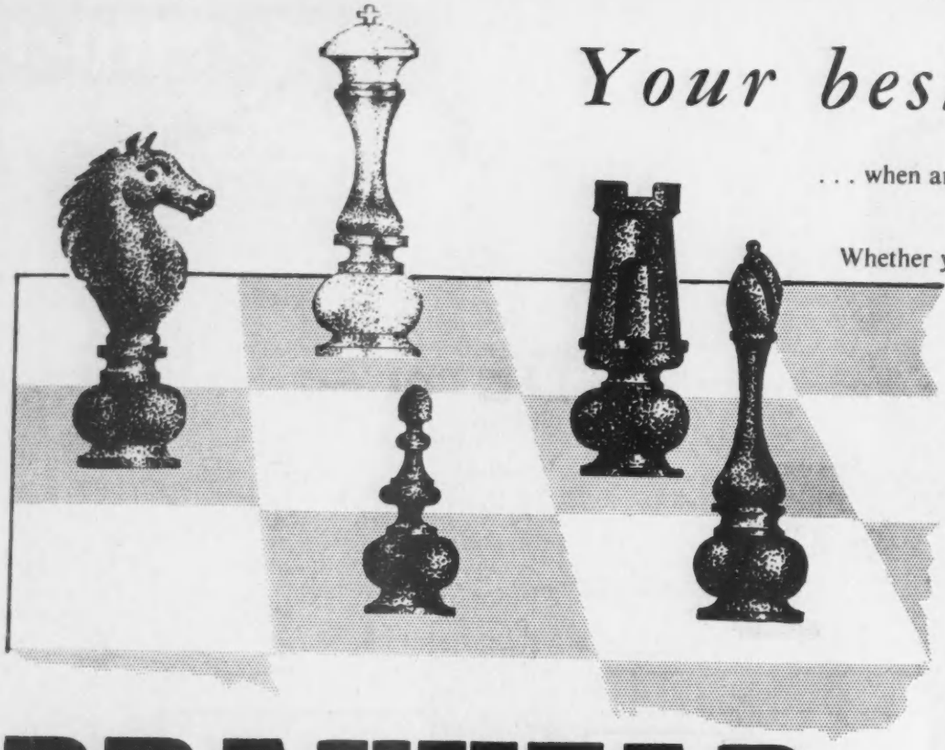

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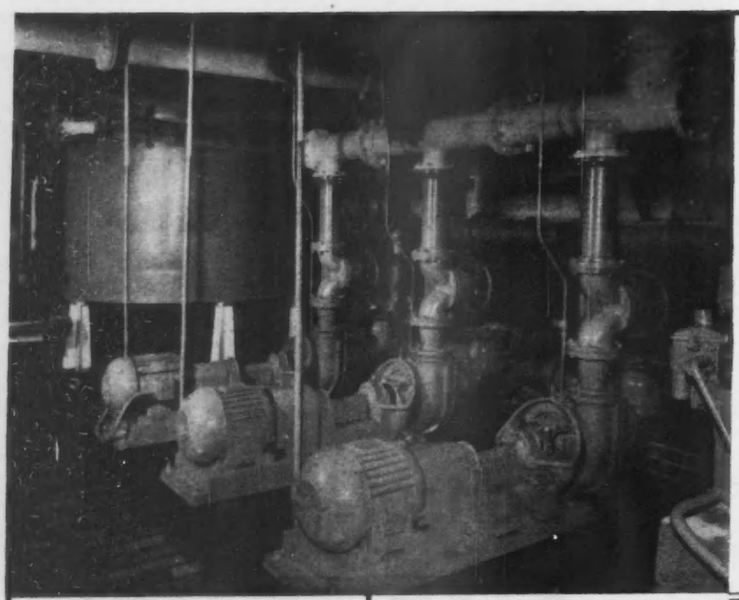

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Sulphuric Acid and contaminated wash waters on pickling tanks and continuous pickling plants

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Waste pickle liquor and acidic effluents for neutralisation prior to disposal

Pumping of demineralised water

(Top left) Large battery centrifugal acid pumps
(Bottom left) Close-up view of diaphragm pump similar to the hand operated unit but arranged for motor drive
(Bottom centre) Hand operated portable diaphragm pump for emptying carboys or tanks and for general duties.
(Bottom right) Portable rotary displacement pump pumping plating solutions in the motor car trade

MITCHELL PUMPS give complete freedom from metal contamination of the liquids

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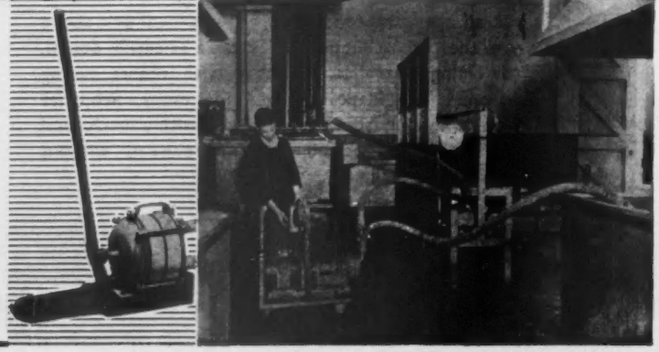

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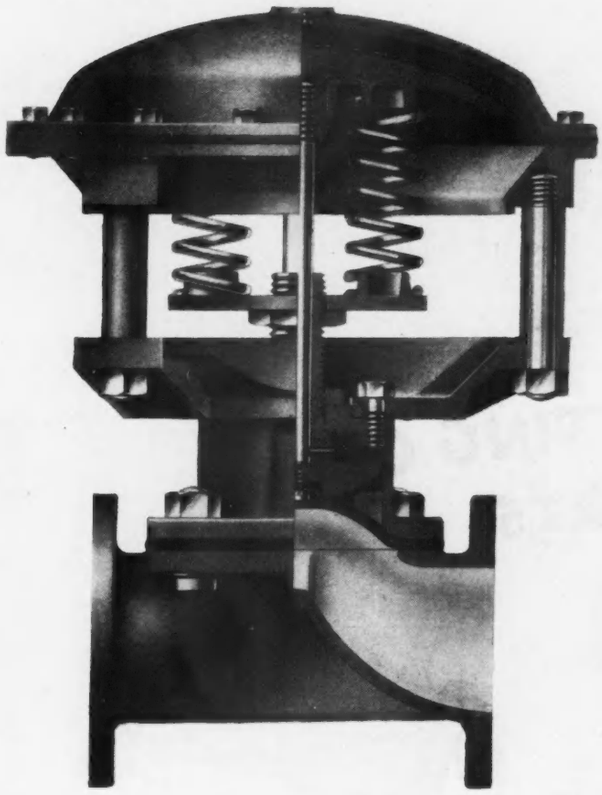

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Many products and processes which to-day are commonplace were impracticable before the advent of Saunders Diaphragm closure and isolation - - The diaphragm makes sure closure and isolates delicate or dangerous fluids from the mechanism.

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To fit pump parts only one spanner is used.

A shifting spanner, Oh Yes

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To union members and non members alike

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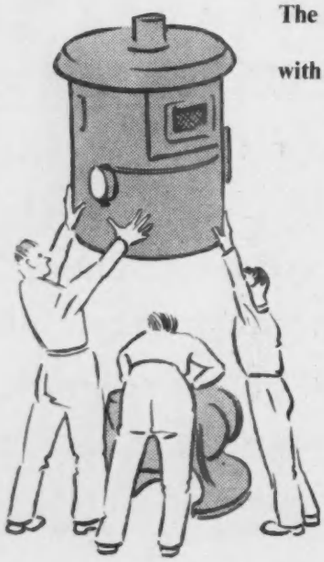
If in doubt call in the Drysdale Service Engineer

His approach to the job is very good.



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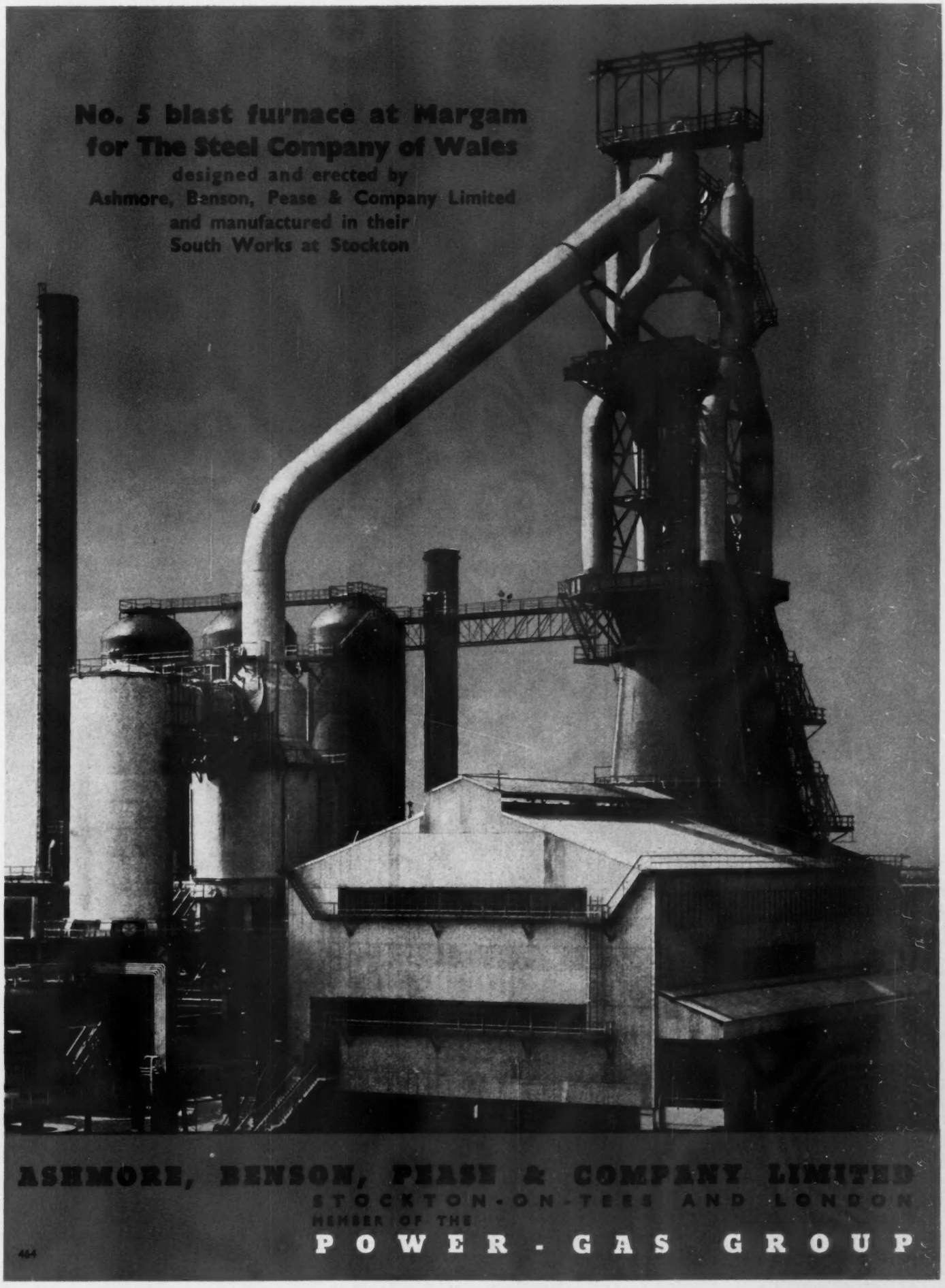
Makers of Pumps
for all Land and Marine Services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for The Steel Company of Wales
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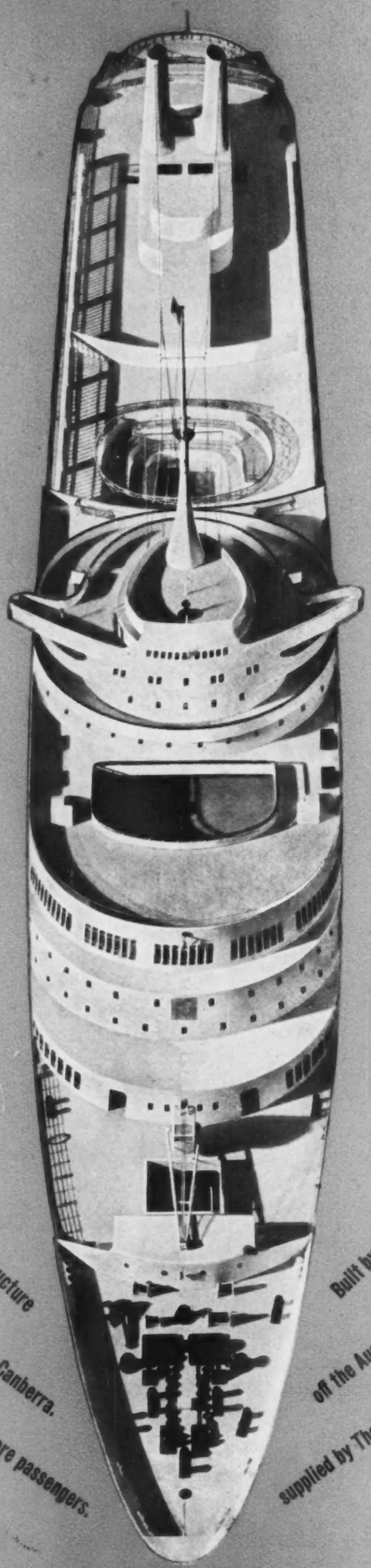
8



One thousand tons of British Aluminium used in her superstructure enabled an extra deck to be incorporated in the Canberra. Accommodation will be provided for up to 300 more passengers.

Built by Harland & Wolff Ltd, this new P & O liner will clip 6 days off the Australian run—aided by the use of light-weight aluminium supplied by The British Aluminium Company Limited.

AP486

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INTRODUCING THE ECCO 40

A new, even better spray-gun developed from the highly successful ECCO 30

- ✳ **Large air ducts and effective nozzle combinations for greater capacity**
- ✳ **New packing system for paint needle prevents leakage**
- ✳ **Ease of operation—comfortable pistol grip... long, two-finger trigger... single hand adjustment of fluid and fan controls**
- ✳ **Interchangeable paint and air connecting nipples**
- ✳ **Few parts simplify maintenance**

Based on the highly successful Ecco 30, the Ecco 40 has even greater capacity and is easier to operate and maintain. The gun has a light, durable body of modern design and a range of nozzle combinations enabling it to be used for all spray-painting jobs.

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All over the world, the name of 'Jaguar' means performance and good looks. At their Coventry works—where craftsmanship is allied to modern production methods—Jaguar Cars Ltd., have introduced Ecco 40 guns to apply the finishes for which they are famous.

A COMPLETE RANGE OF COMPRESSED AIR EQUIPMENT

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies and agents in ninety countries throughout the world.

Photograph by courtesy of Jaguar Cars Ltd.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden.

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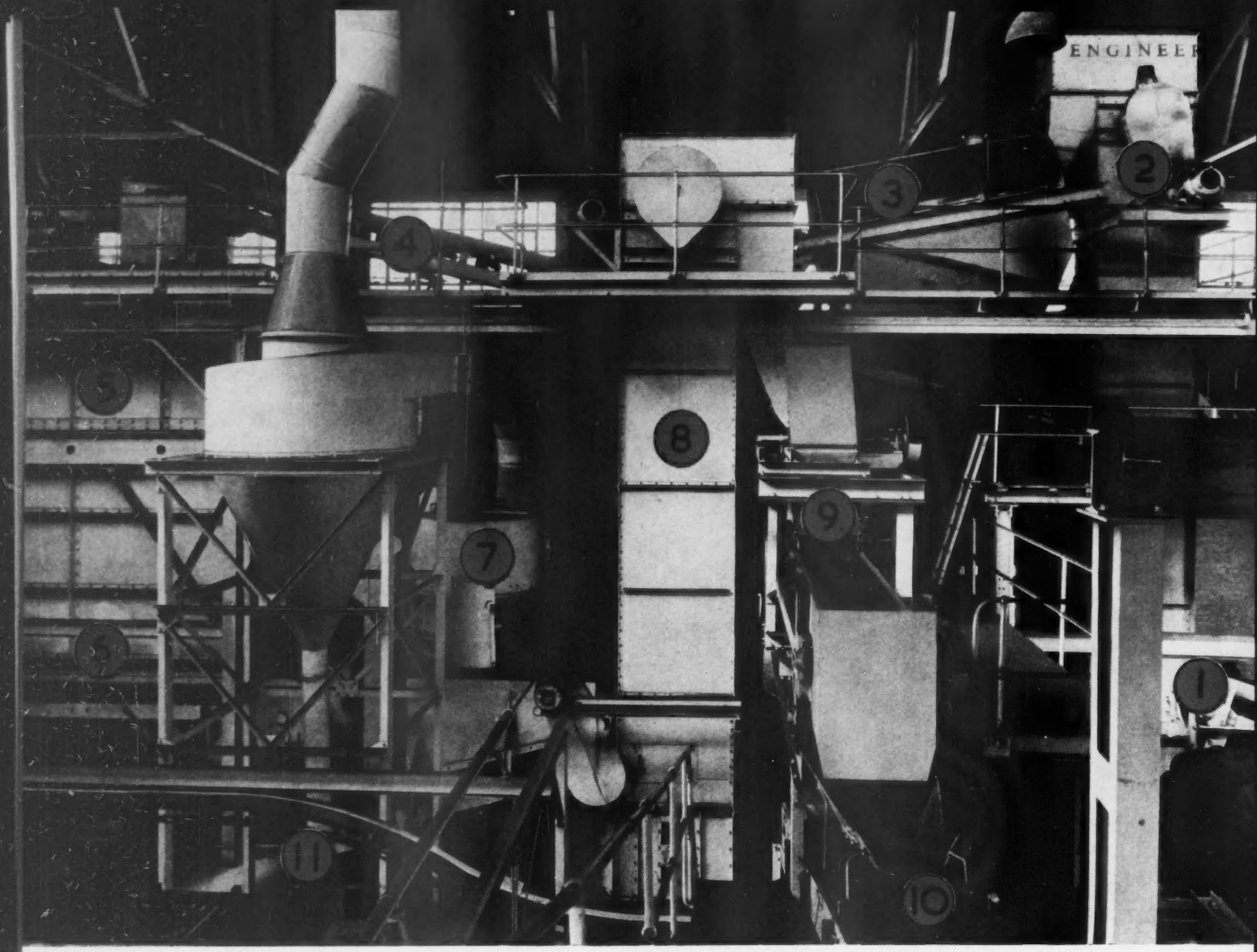

The illustration shows that part of a **MORRIS** foundry sand and mechanization plant which reconditions knocked-out sand. At **1**, sand coming from the knock-out via an apron plate and belt conveyor passes beneath a magnetic separator (to remove tramp iron) and falls into the boot of a belt-bucket elevator **2**, discharging into screen **3** onto belt conveyor **4**, which in turn discharges into sixty-ton storage hopper **5**. The flat belt conveyor **6**, under the hopper, pours sand into the skip which feeds the mulling machine (known as the Speedmullor). This machine **7**, providing a rapid mulling cycle with close batch control, discharges the sand into belt-bucket elevator **8**. From thence, the sand proceeds via belt conveyors **9** and **10** to the moulders. The overhead chain conveyor **11** serves the core shop with sand and also takes the cores to the stoves and to the moulders.

MECHANICAL HANDLING EXHIBITION
EARLS COURT
3-13 MAY
SEE OUR EXHIBIT
ON STANDS H.12 & J.14

Consult MORRIS

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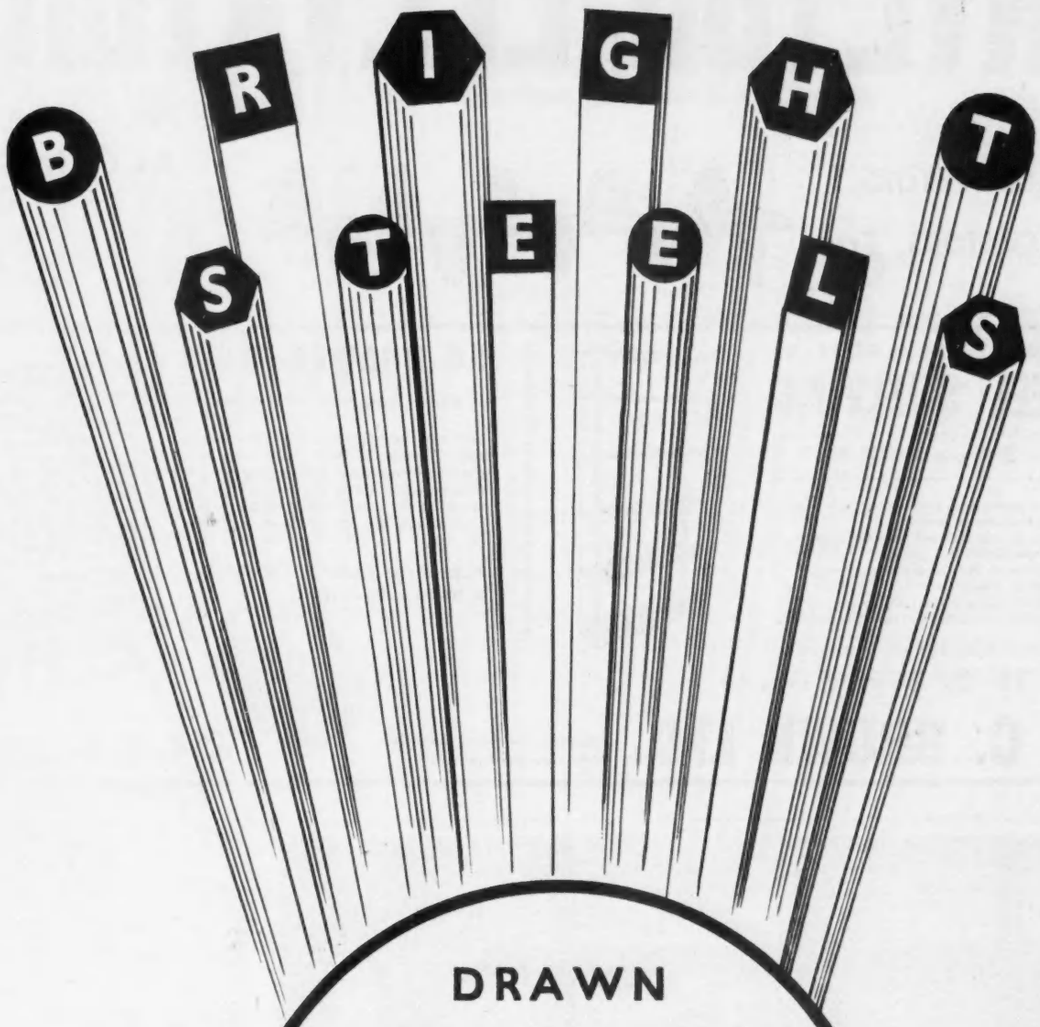

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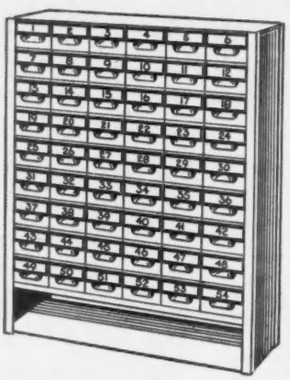
* *Send for SAMPLE DRAWER without obligation.*



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The large Compressor illustrated is typical of our 'Comoblok' range of machines. This range covers capacities from 500 — 2,000 c.f.m. These machines are of the double-acting crosshead type, and are suitable for pressures up to 50 p.s.i.g. single stage, and 150 p.s.i.g. two stage. They are remarkable for their low power consumption and compact design.
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The machine alongside is one of our Oil-free Range. These are available in capacities from 100 to 2,000 c.f.m., and at all pressures up to 150 p.s.i.g. They are specifically designed to deliver uncontaminated air, and have many special features incorporated which make them unique in this field of Compressors. Send for Leaflet No. T31.

The two smaller machines shown illustrate our 'Uniblok' and 'Twinblok' Range, and cover capacities of from 50 to 400 c.f.m. at all pressures up to 120 p.s.i.g. These are of the single stage, single acting type. Are styled to give a neat appearance and are unrivalled for their low maintenance and space saving features. Send for Leaflet No. T19.

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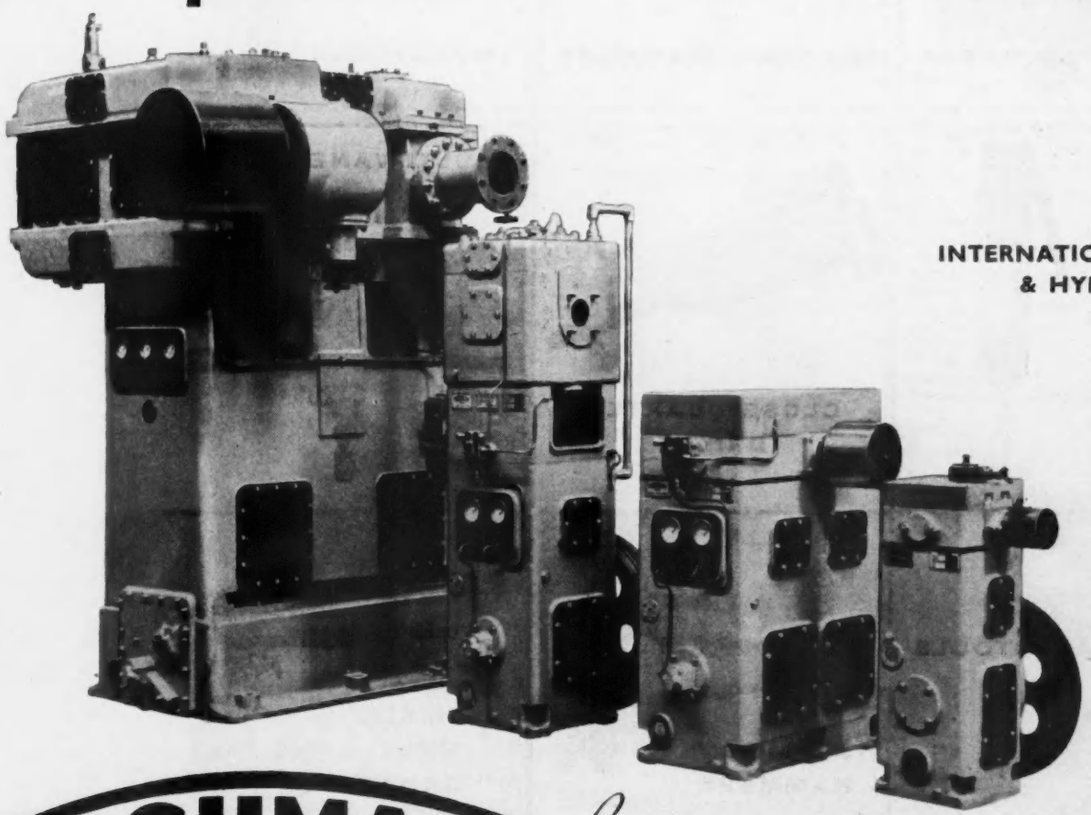
Tilghman's undertake the design and manufacture of special purpose Air & Gas Compressors, Boosters, etc., and welcome an opportunity of quoting for complete installations.



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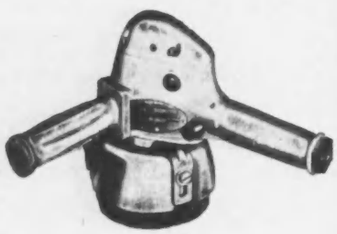
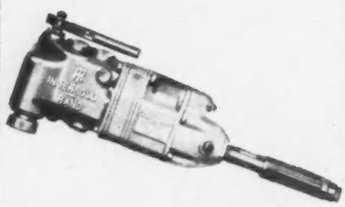


SURFACE GRINDERS

CHIPPING HAMMERS

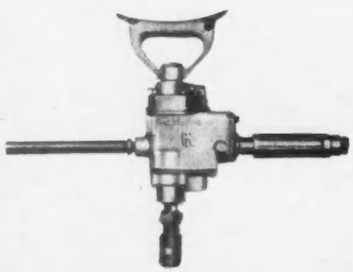
IMPACTOOLS

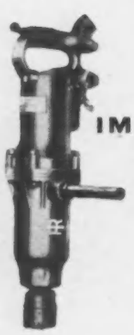
WELD FLUX SCALERS



CLOSE QUARTER DRILLS

MULTI-VANE DRILLS





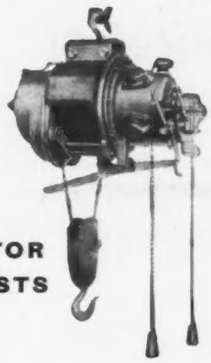
IMPACTOOLS

SCALING HAMMERS

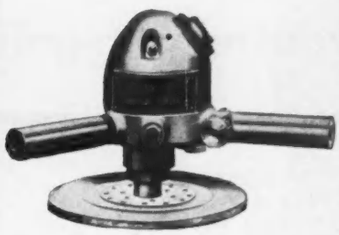
SMALL MULTI-VANE DRILLS

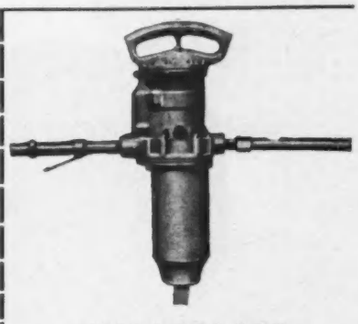
P.3781

MOTOR HOISTS



SANDERS



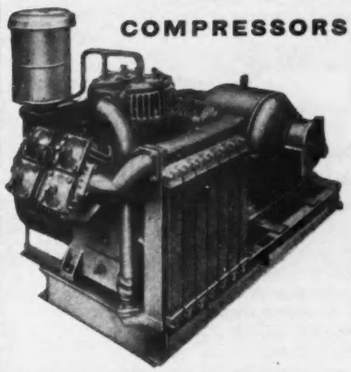


IMPACTOOLS

GRINDERS

MULTI-VANE DRILLS

COMPRESSORS



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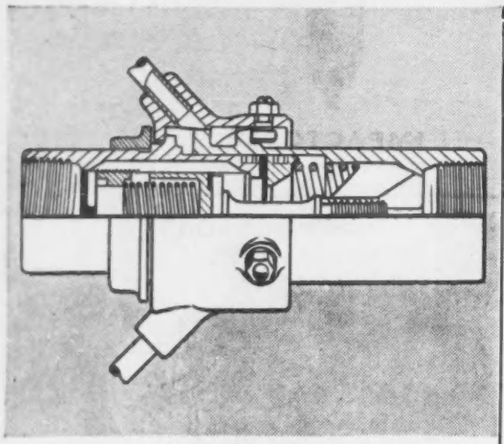
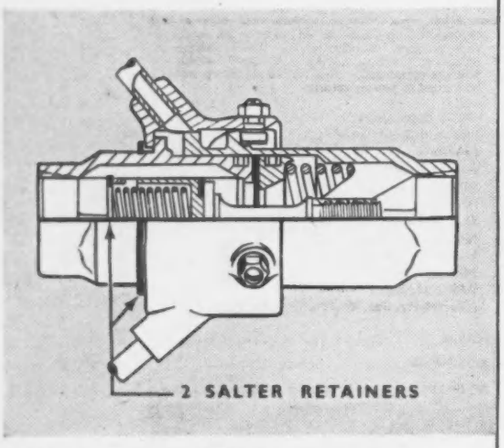
How costs are cut with SALTER RETAINERS

Salter retainers simplify design of self-sealing coupling with great savings



THE OLD WAY Self-sealing coupling used over-sized internal and external threaded retainers . . . costly milling, turning and threading operations were necessary and assembly slow and difficult.



THE SALTER WAY Two Salter Retainers replace heavy threaded retainers, and eliminate many costly tooling operations. Assembly, disassembly and maintenance is simplified.

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outer shoulder ring (15 mins)	4/-
inner retainer (20 mins)	5/4¼
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ASSEMBLY	6¼
total labour saving	10/11
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brass threaded retainers	3/5
TOTAL SAVING WITH SALTER RETAINERS	14/4

* **14/4 saved on each unit by use of 2 SALTER RETAINERS**

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NEATER – MORE POSITIVE – PERMANENT RETAINING

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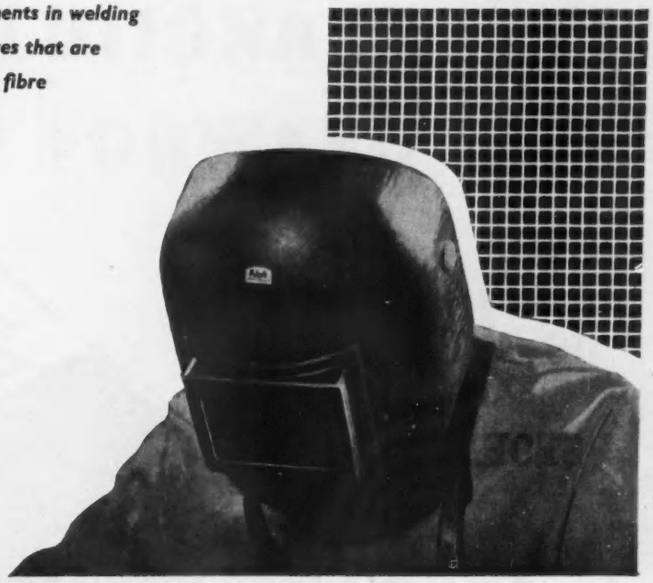

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SUPERWELD 800 SERIES

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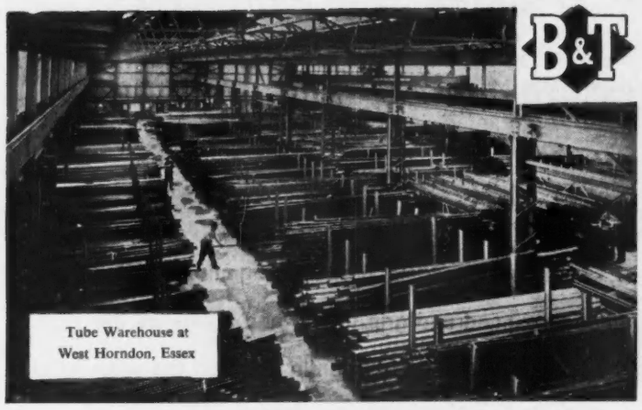

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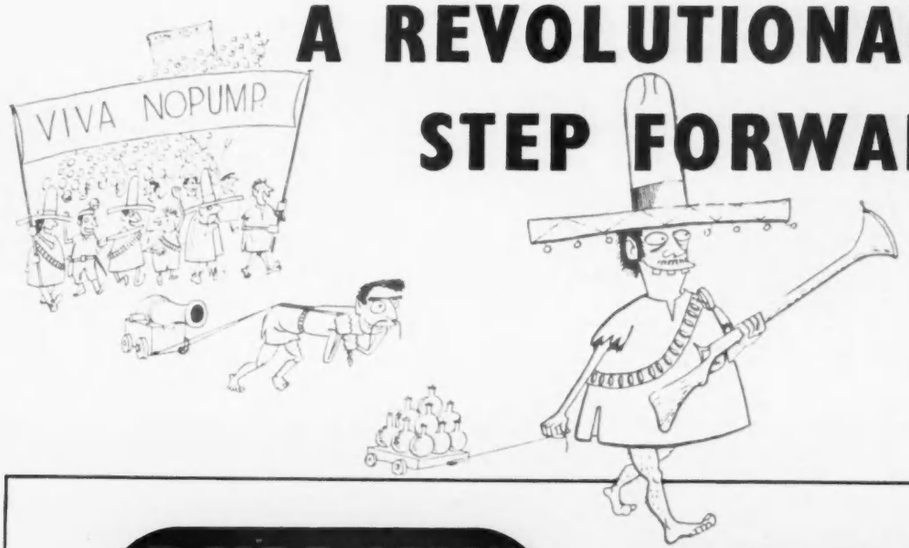

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Please arrange for a representative to call with full details of your NOPUMP Spray Booths.

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NO CLEANING OUT AFTER 1 YEAR'S CONTINUOUS DOUBLE-SHIFT WORK

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This Booth was started up on production on 1st March, 1959, and ever since has operated two nine-hour shifts on continuous painting of agricultural machinery.

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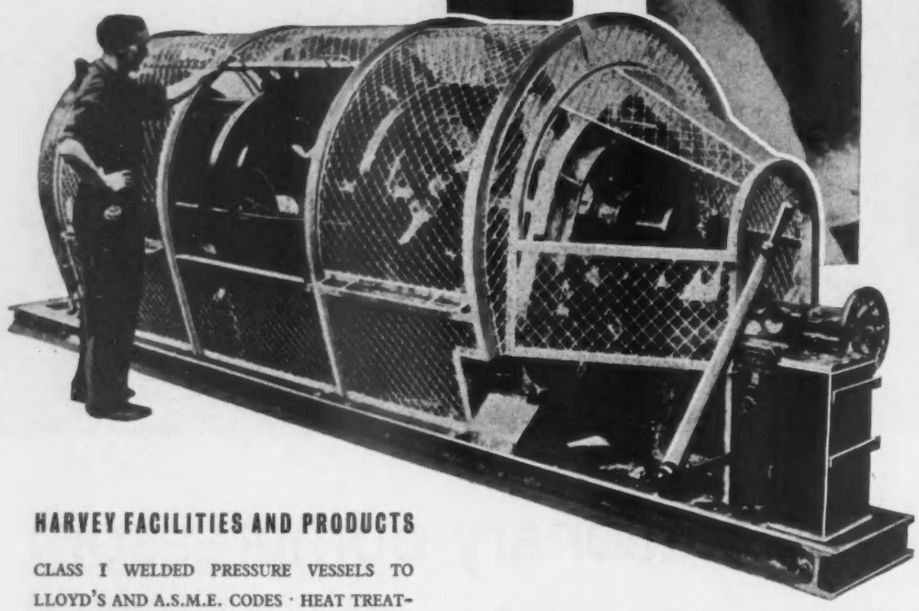

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'Harco' Machinery Guards are purpose made for every type of machinery, and are constructed to afford complete protection without interfering with efficient operation. They are strongly made from stout wire mesh to withstand vibration and rough treatment, and all 'Harco' Guards fully conform to Factory Act requirements. The complete Harvey service covers advice, design and installation, and List No. 996 shows many types already supplied.

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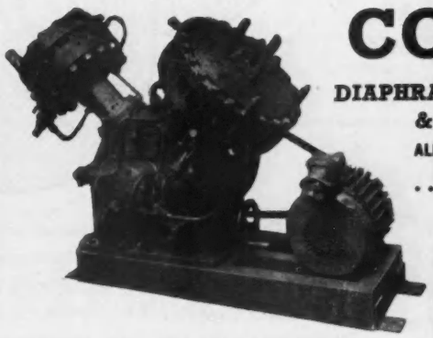

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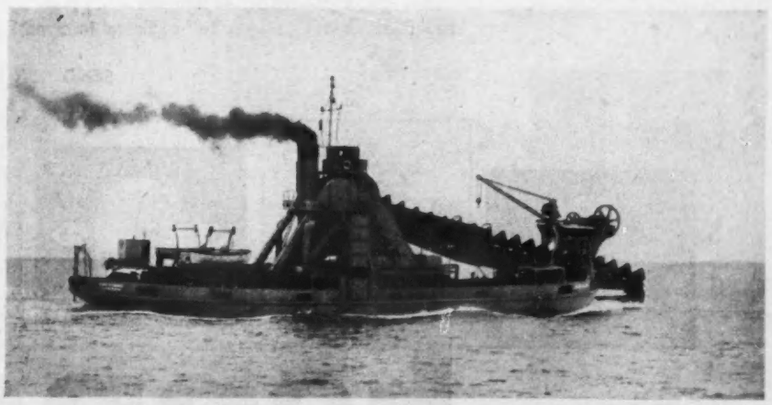
New Buckets, Links, Pins, Gearing, etc, supplied for existing Dredgers.



Twin Screw Bow Well Bucket Dredger "Abertawe" constructed for the Great Western Railway Company. Dimensions: 160ft. x 40ft. x 14ft. Speed: 8½ knots. Buckets: 27 cub. ft. Specified Dredging Output: 900 tons per hour.

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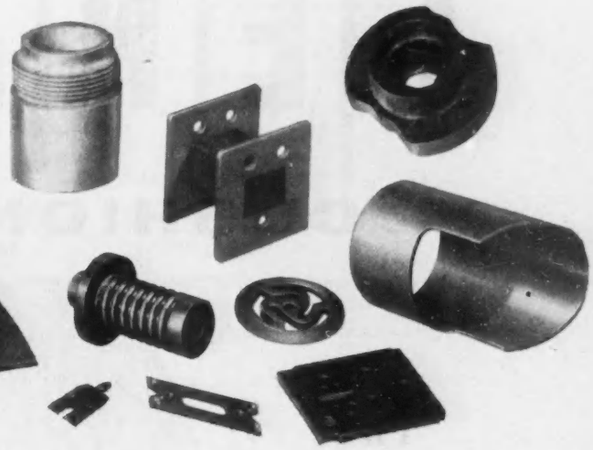
Examples of Paxolin punchings, mouldings and machined parts.



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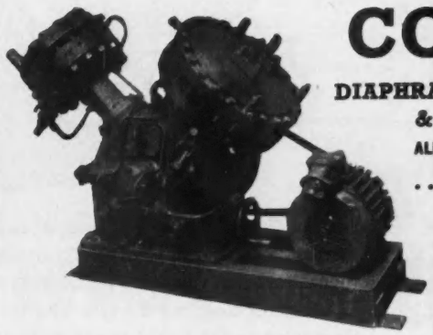

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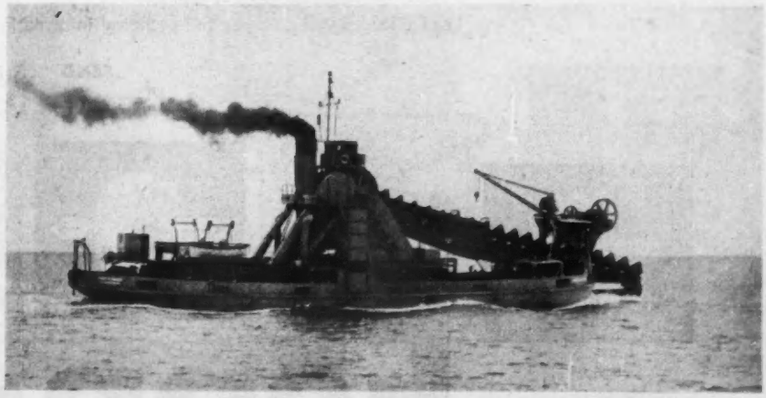

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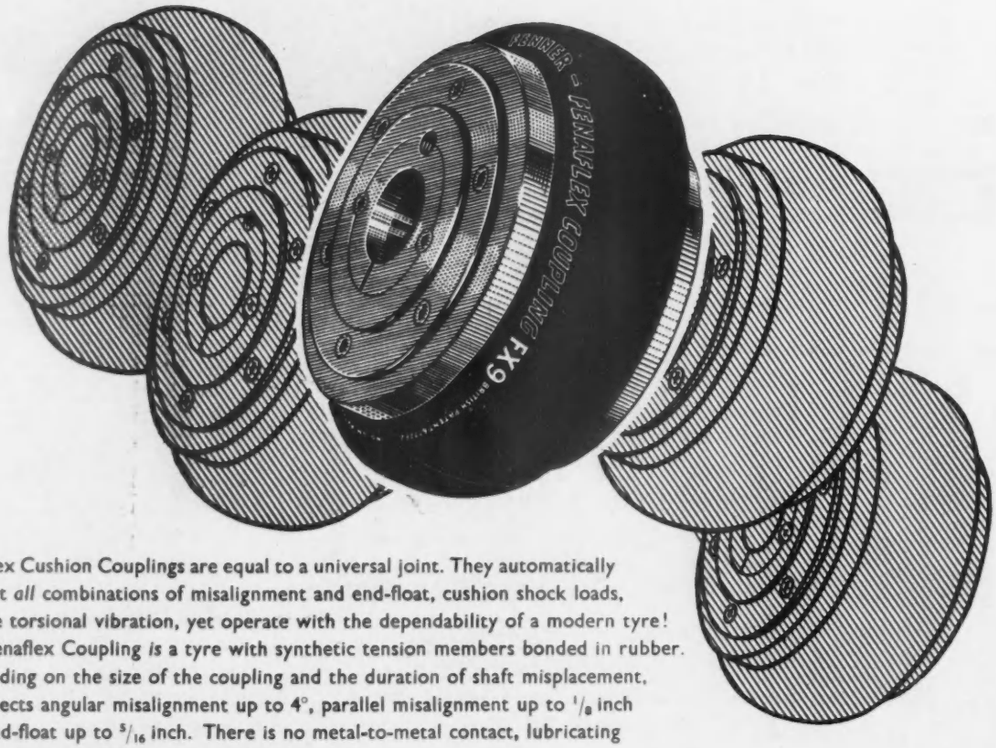

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Leaflet 353/18 will give you full technical information.

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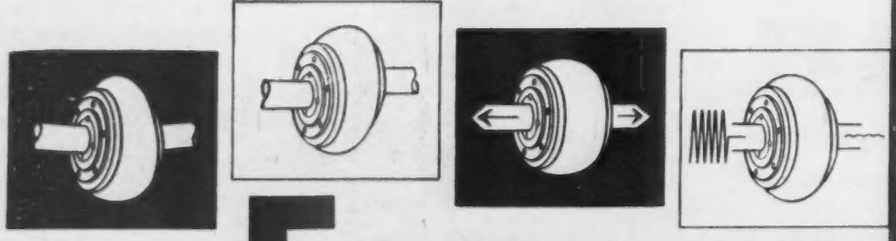

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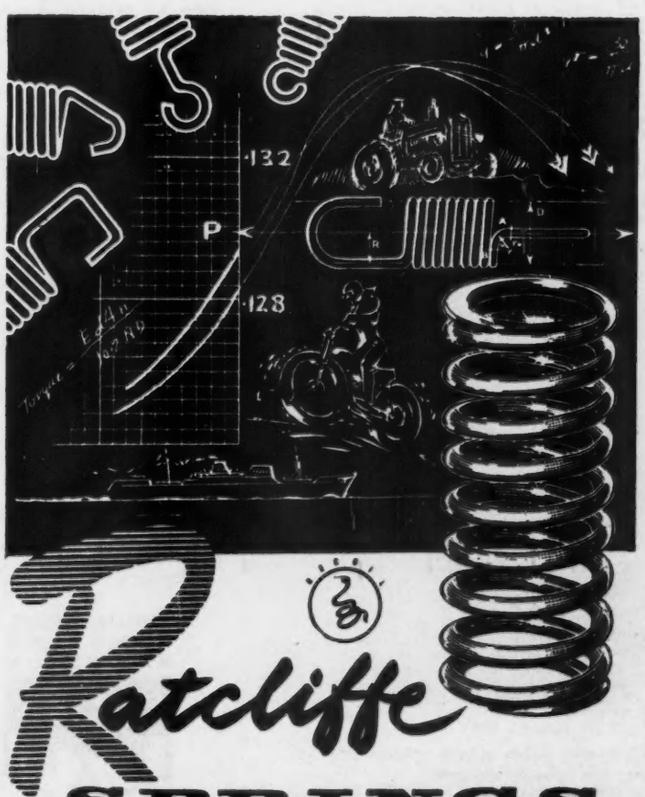

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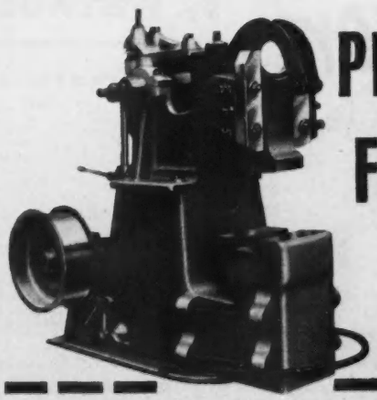

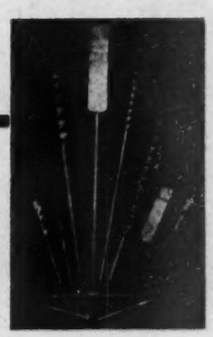

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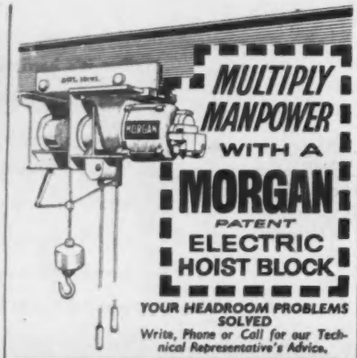

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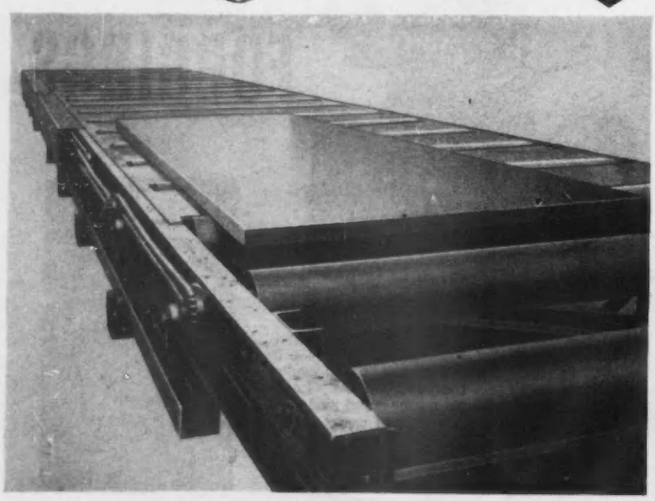

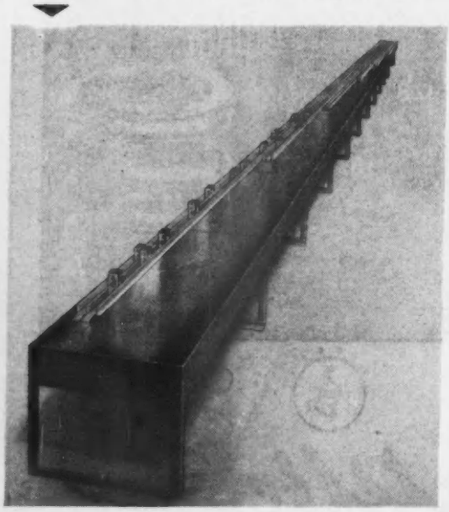

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Left : A heavy duty, powered roller conveyor carrying 2in. thick steel plates.
Right: A 100ft. long conveyor with twelve separate belts carrying ¼ lb. packets of tea.

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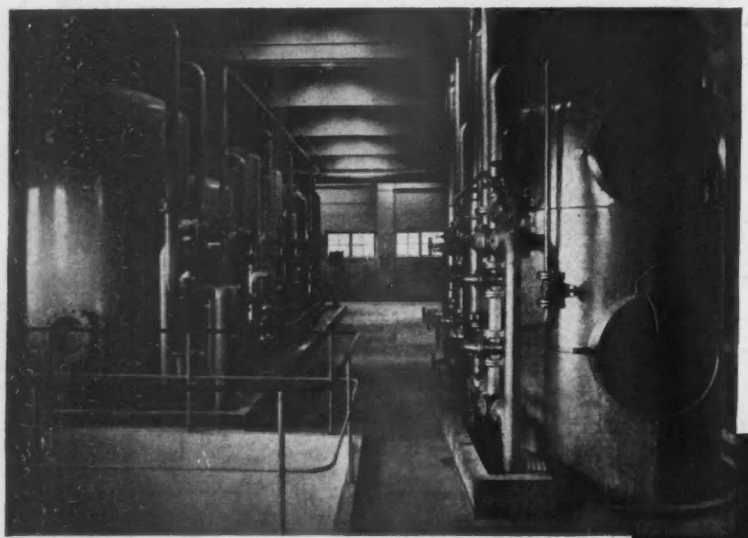
Boiler pressure 1,750 psi, 42% make-up



Demineralisation Plant for Boiler feed make-up, capacity 13,400 g.p.h. and base-exchange softener for condensate returns, capacity 18,000 g.p.h.

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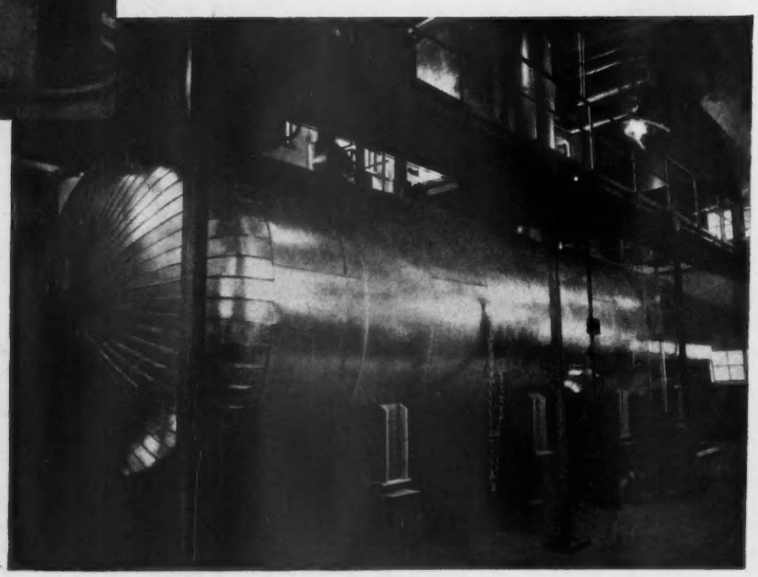
All plant made in Finland to the designs of William Boby & Co.



Deaeration Plant, capacity 250,000 p.p.h. with 30 minutes storage.

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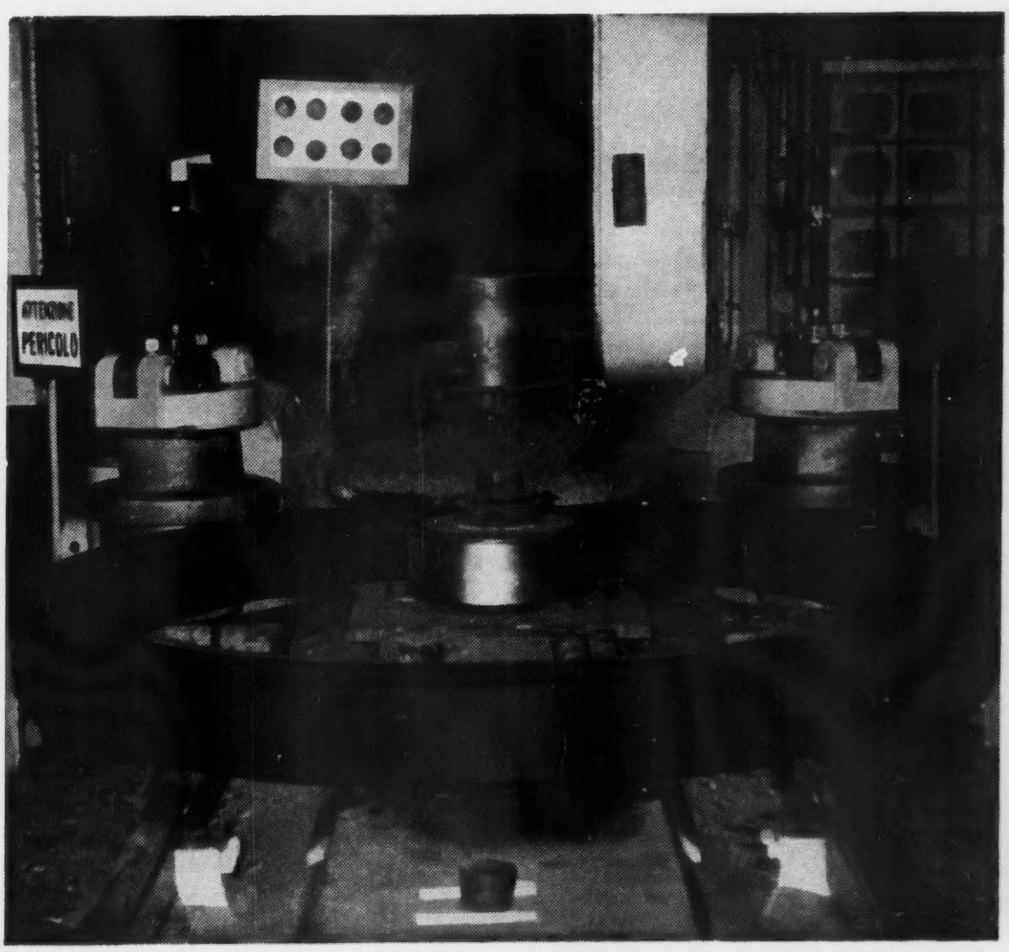

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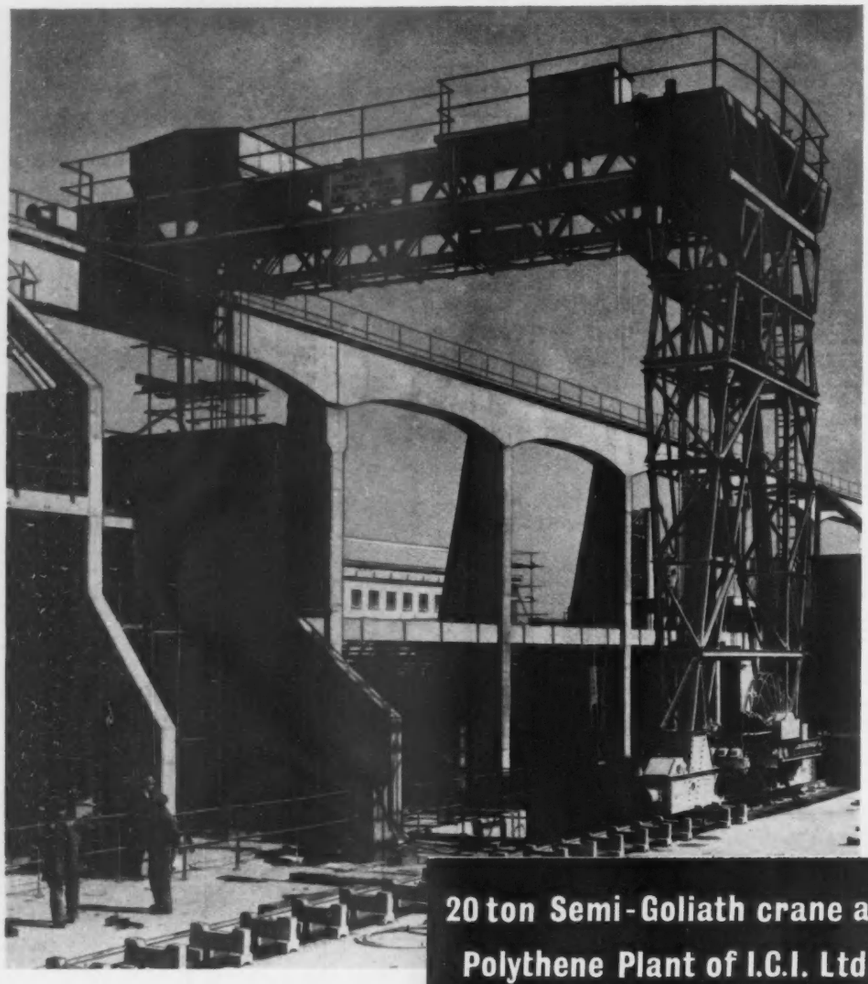
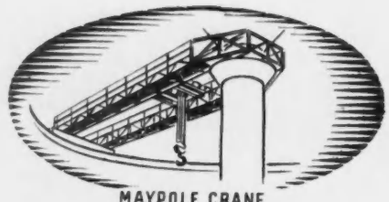


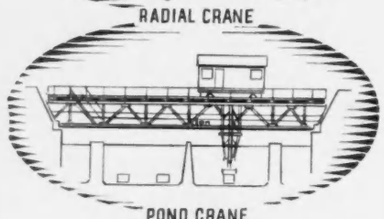
20 ton Semi-Goliath crane at Polythene Plant of I.C.I. Ltd



MAYPOLE CRANE

CIRCULAR CRANE

RADIAL CRANE



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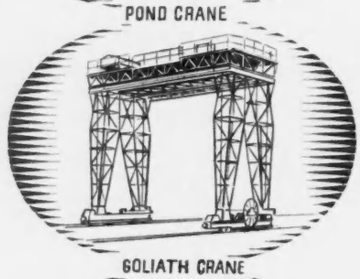
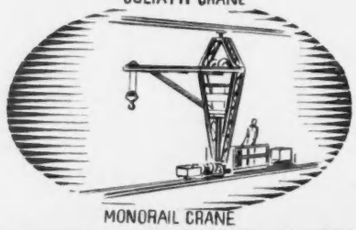


GOLIATH CRANE



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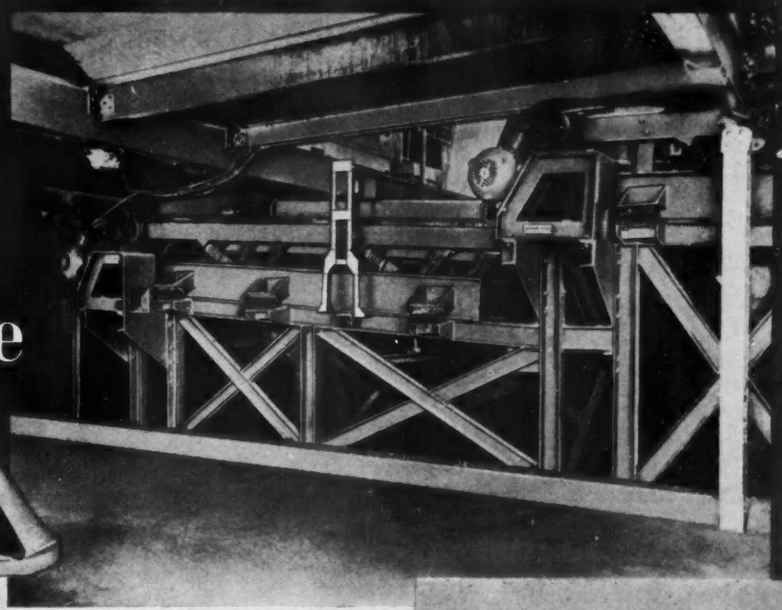

Cushioning the shocks stops metal fatigue

Maintenance on screens at the Lynemouth (Northumberland) colliery has been greatly reduced by the application of Metalastik anti-vibration mountings.

The Lynemouth washery is one of the largest single units in the United Kingdom and large amounts of coal are handled per hour on screens operating several hours a day. In February 1956, the No. 1 Primary Spray Screen and the No. 1 Primary Drainage Screen were placed on Metalastik Cushyfoot mountings.

Vibration and noise were immediately reduced.

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Silent, unlubricated and resilient, the various forms of Metalastik bushes for permitting pivotal movement have been well-proved by the millions in successful use.

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Evaporation . . . 1,400,000 lbs. per hr.
Steam Pressure . . . 2,450 p.s.i.g.
Superheat Steam Temperature . . . 1,060°F
Reheat Steam Temperature . . . 1,005°F

550 MW

This capacity from a single boiler unit will be greater than that of any other known design in the world. The 550 MW twin furnace unit to be installed at THORPE MARSH Power Station will have the following operating conditions:

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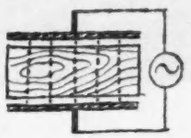
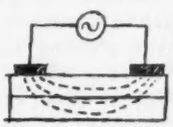
Electrical Aids in Industry *Data Sheet* **No. 10**

Dielectric Heating - 1

When an electrically non-conducting material is placed between two metal plates, called electrodes, connected to an A.C. supply, the alternating electrostatic field between the electrodes considerably speeds up the molecular movements in the material (termed a 'dielectric') as a result of which the temperature of the material under treatment rises. A similar effect is produced where the two electrodes are positioned on the same side of the dielectric; in this case the electrostatic field between them is generally known as a 'stray' or 'fringe' field. For industrial application, the applied voltage of the order of 15,000 volts supplied by an electronic generator alternates at frequencies of some millions of cycles per second.





The amount of heat generated in the dielectric is determined by the frequency, the square of the applied voltage, the dimensions of the object and a physical property of the material termed 'loss factor' and is represented by the equation :—

$$\text{Power} = 1.41\ E^2\ f.\ F\ \frac{A}{t}\ \times 10^{-12}\ \text{kilowatts.}$$

Where E = applied voltage, f = frequency, F = loss factor.

A = area of the dielectric in square inches.

t = thickness of the dielectric in inches.

F, the loss factor, is itself equal to the expression K Cos Ø in which :

K = the dielectric constant, a measure of the property of the material to retain energy arising from disturbance of its molecular structure.

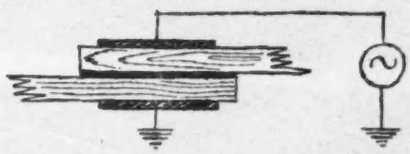
Cos Ø = the dielectric power factor of the material, i.e. the ratio of the power (in watts) to the product (in volt-amperes) of the voltage and current. This is a characteristic property of the material.

Therefore, 'loss factor' is a property of the material and a measure of the ease with which it can be heated by this method. Like other physical properties, it varies considerably for different substances. The equation shows that the heat generated in a dielectric is proportional to its loss factor, but the rate of rise of temperature will also depend upon its specific heat and density. The following table gives approximate values of the dielectric constant, power factor and loss factor of a few typical dielectric materials for frequencies around a million cycles a second.

MATERIAL	DIELECTRIC CONSTANT	POWER FACTOR	LOSS FACTOR
Natural Rubber	2·9	0·02	0·058
Oak, dry	3·3	0·04	0·132
P.V.C.	5·3	0·06	0·318
Urea formaldehyde	7·0	0·03	0·21
'Bakelite' resin	6·0	0·03	0·18
Nylon	3·7	0·05	0·185
Water, pure	80·0	0·03	2·40
Water, tap	80·0	0·5/5·0	40/400

The high loss factor of water means that materials which are difficult to heat when completely dry will often heat efficiently when moisture is present. The voltage must be increased towards the end of the process in some cases to remove the final moisture traces, the reduction in loss factor as the material dries out providing a safeguard against overheating.

Dielectric heating of a homogeneous material is a straightforward application, heat being generated uniformly throughout. If the workpiece is made up of a number of materials, each material will heat up uniformly but each at a rate depending upon its loss factor, thermal properties and density. The degree of temperature uniformity throughout the workpiece will then depend upon the extent to which thermal conductivity can equalise different rates of heating.



Such different rates of heating can be turned to good account in certain applications. For example, in wood glue setting, the glue lines heat up much more rapidly than the wood pieces being joined and the glue sets before the wood heats up substantially, wood having a lower loss factor than glue. Dielectric heating does not depend upon any external heat source to transfer heat by conduction, convection or radiation to the surface of the charge and from thence to the interior by conduction.

Instead, heat is generated within every particle of a body placed in the dielectric field and, depending upon the uniformity of such a body, an even and extremely fast temperature rise can be achieved.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone : TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available — "Induction and Dielectric Heating" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

6770/1

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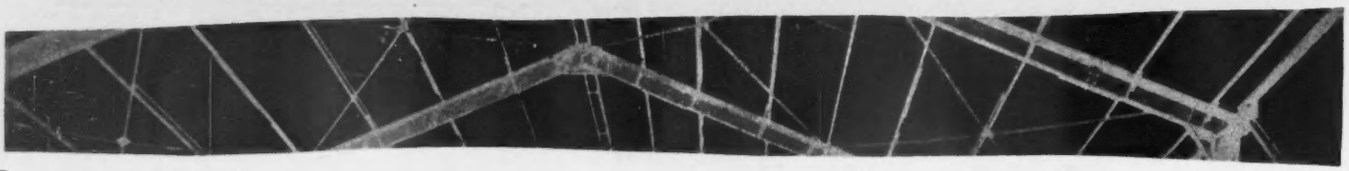
The Portal Roof...



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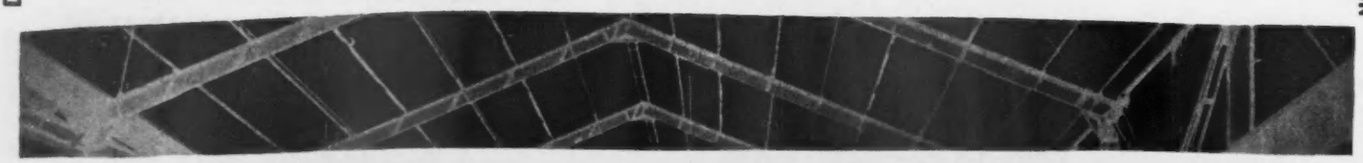

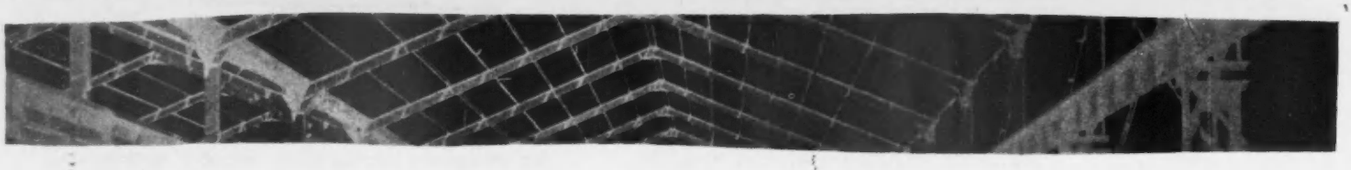

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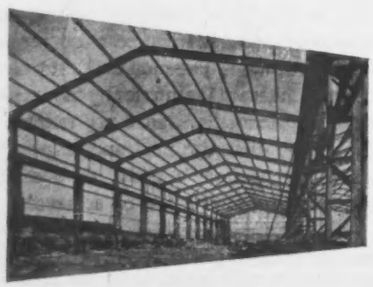

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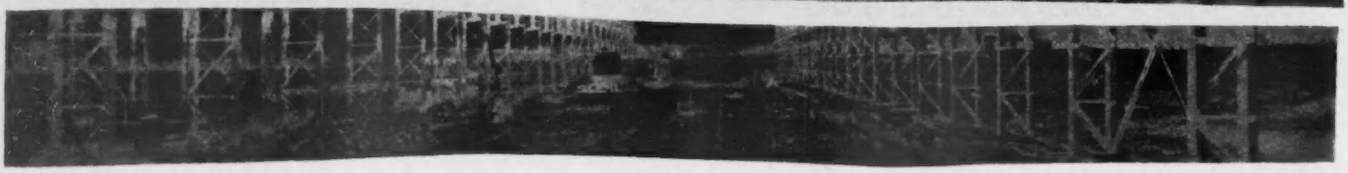

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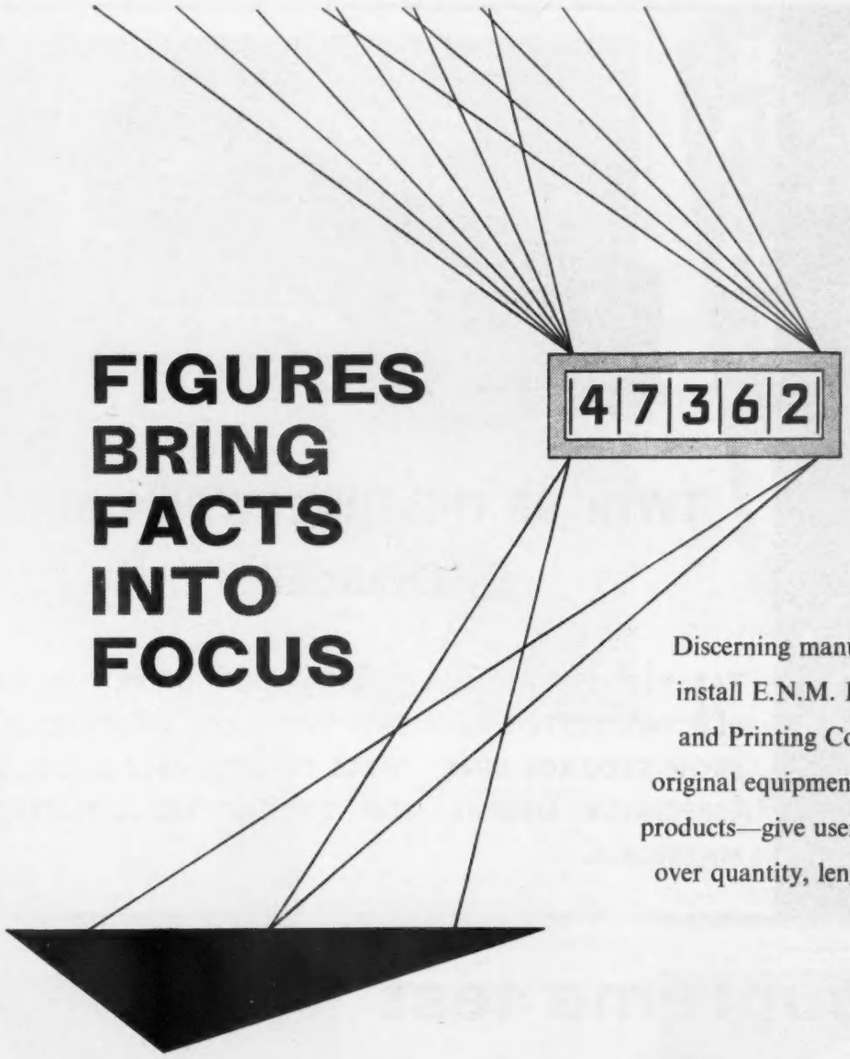
FIGURES BRING FACTS INTO FOCUS



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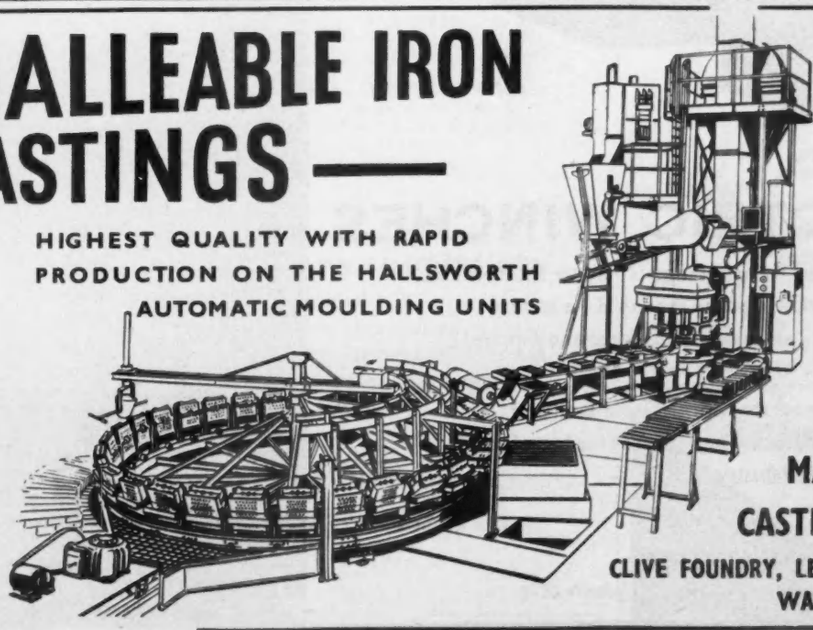

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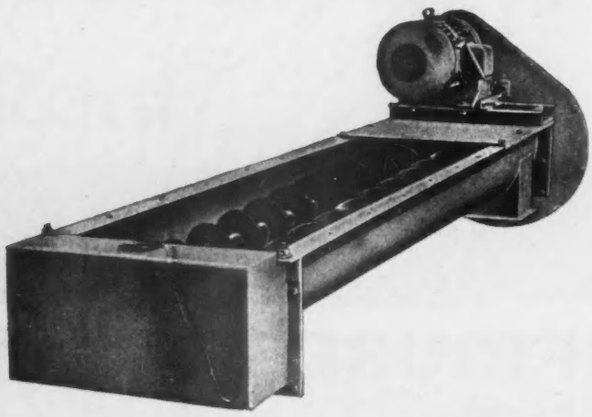

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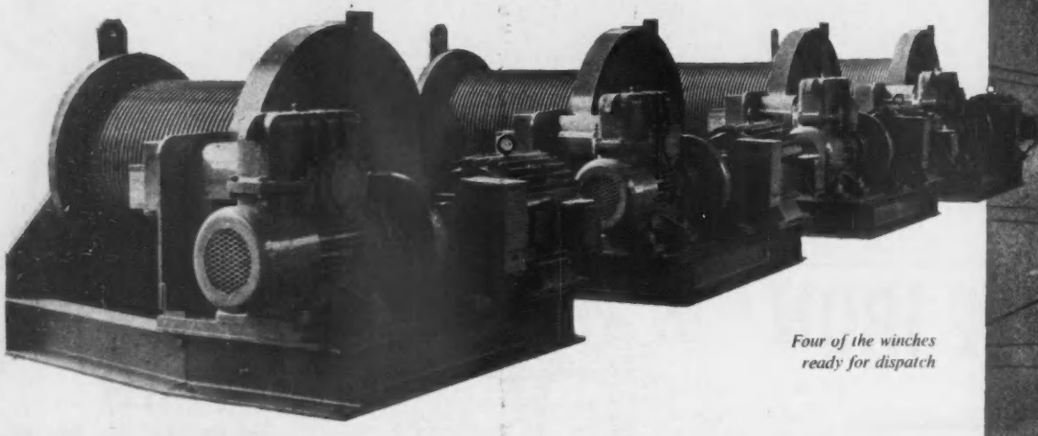
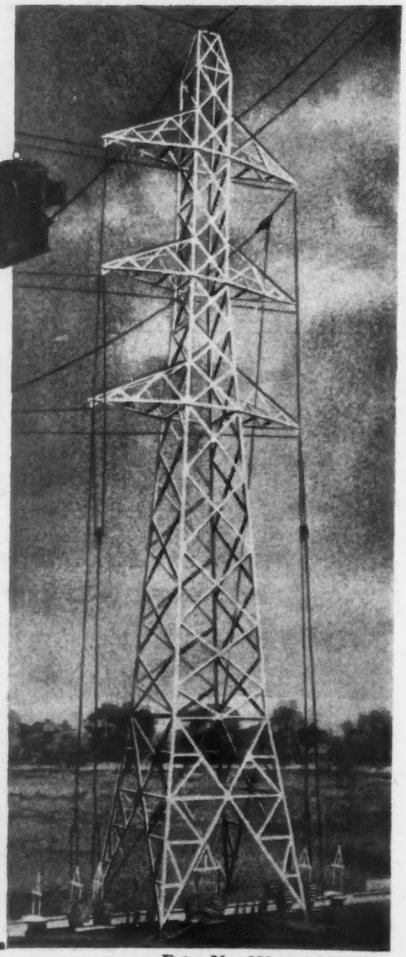


Four of the winches ready for dispatch



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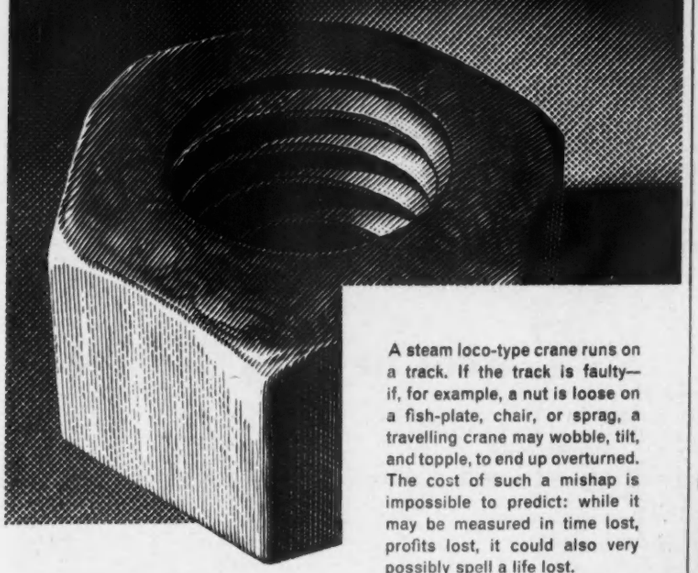

A steam loco-type crane runs on a track. If the track is faulty—if, for example, a nut is loose on a fish-plate, chair, or sprag, a travelling crane may wobble, tilt, and topple, to end up overturned. The cost of such a mishap is impossible to predict: while it may be measured in time lost, profits lost, it could also very possibly spell a life lost.

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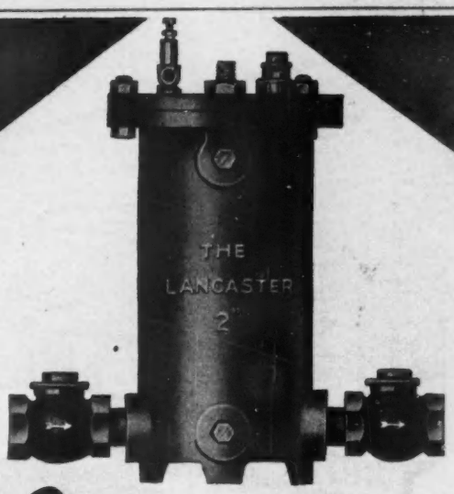

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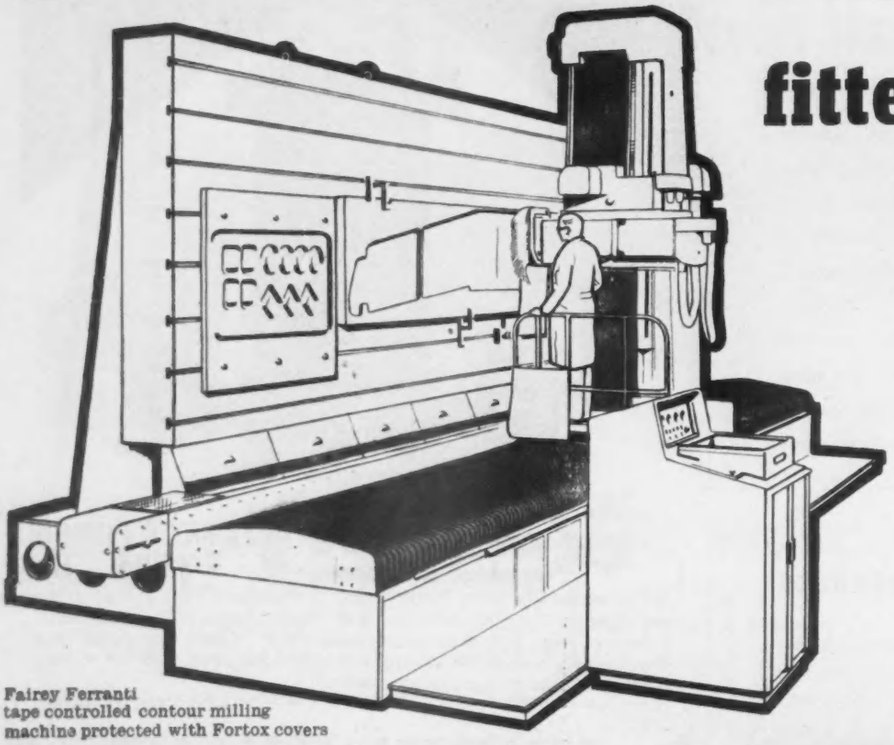

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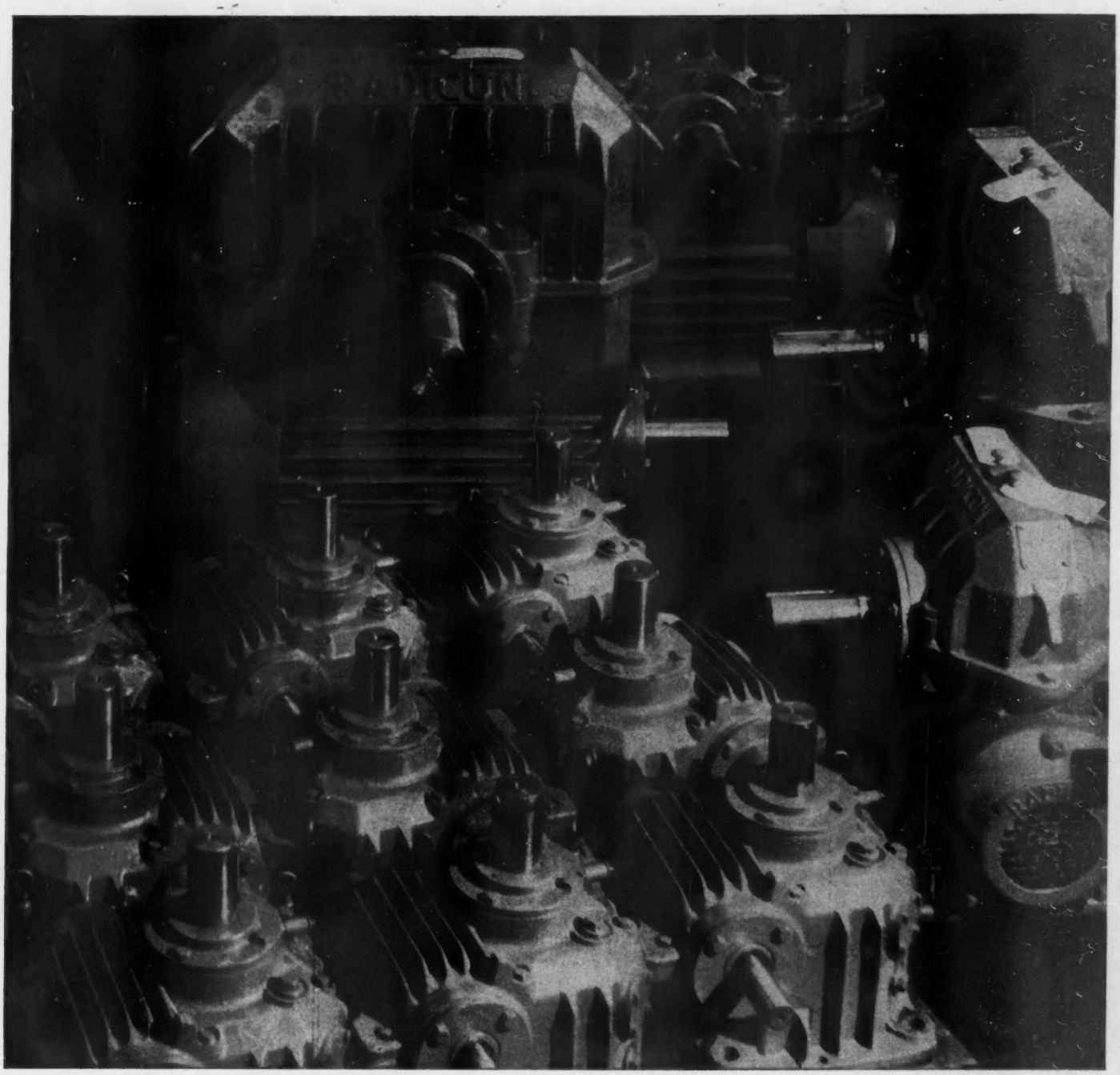

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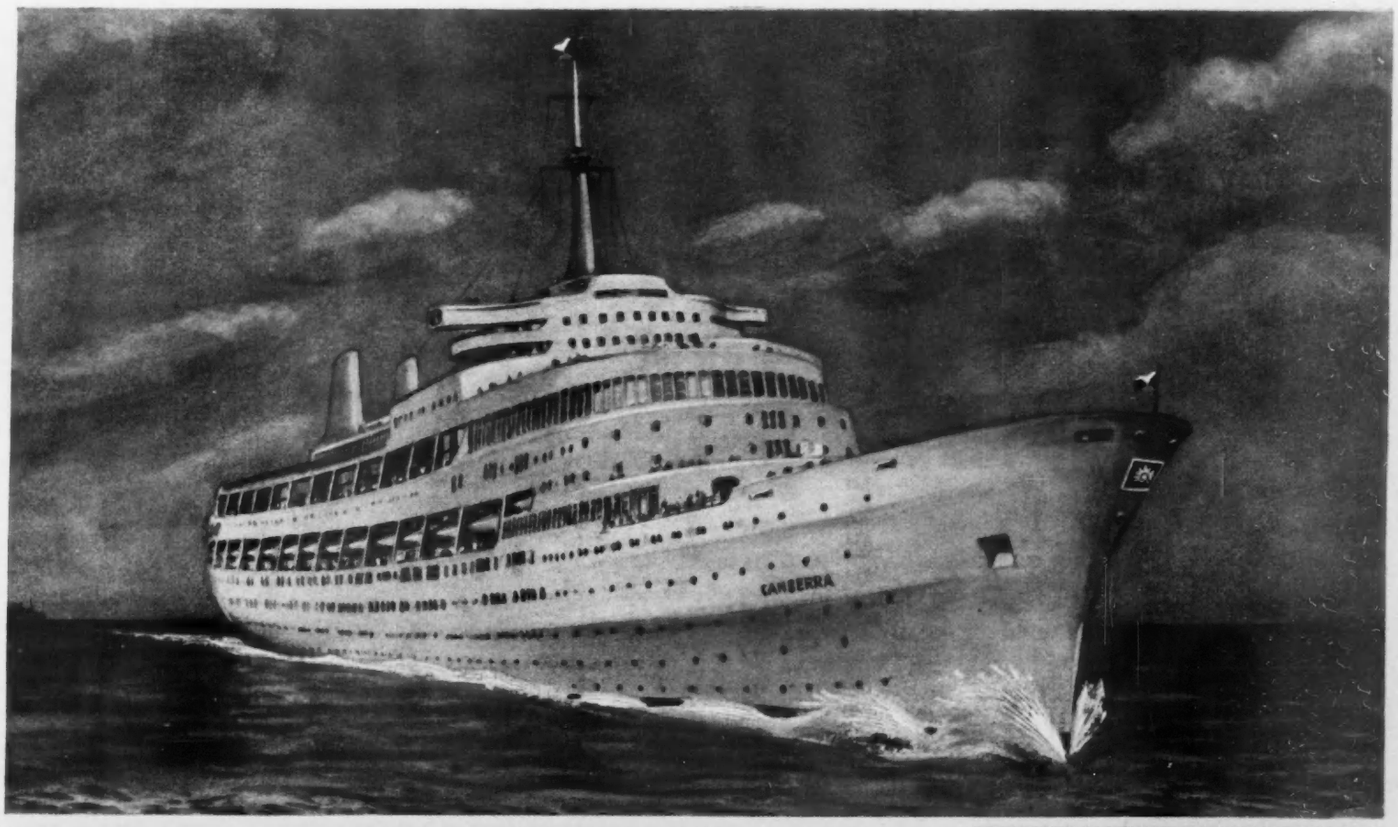

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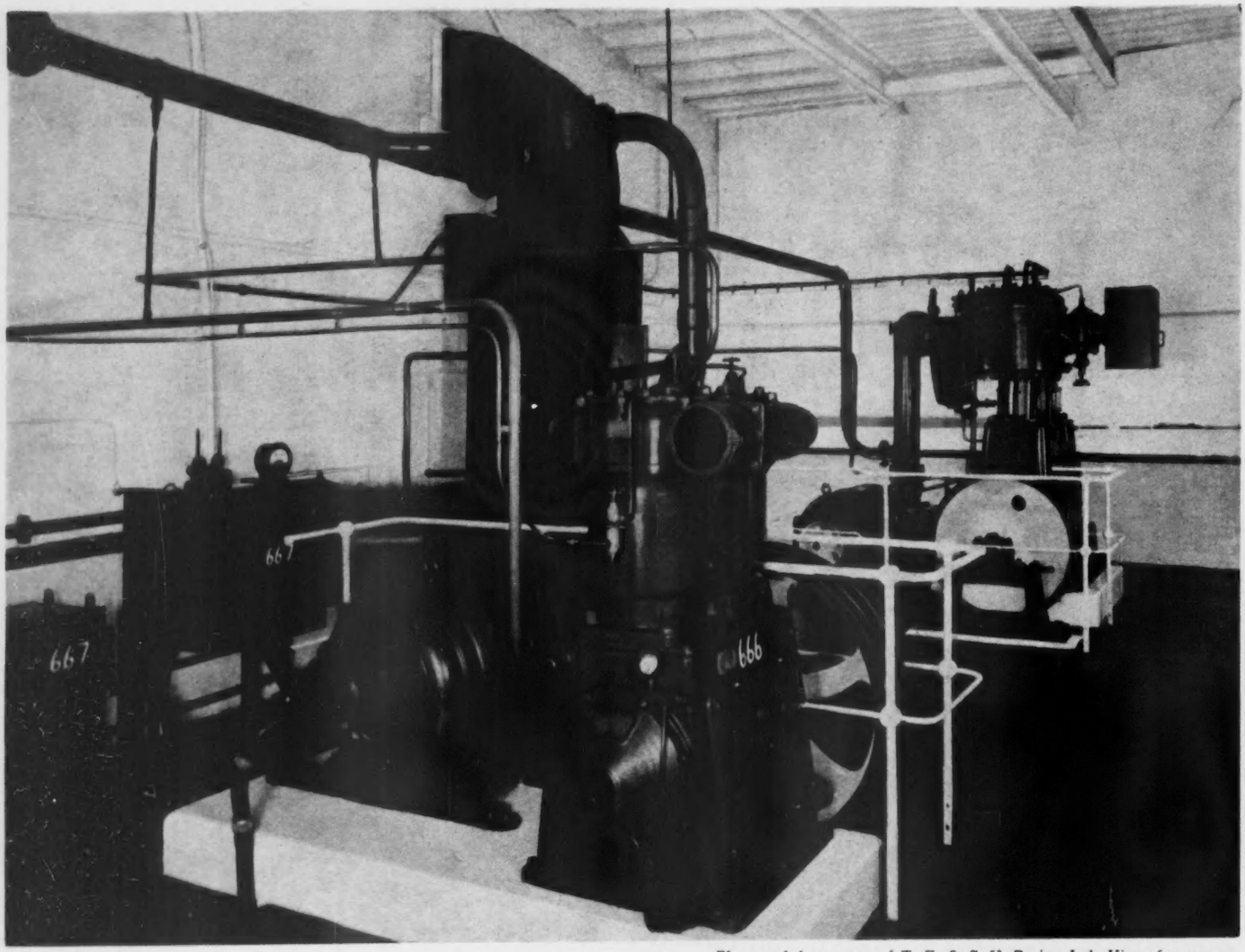

Photograph by courtesy of T. F. & J. H. Braime Ltd. View of compressor house, showing part of the "BROOMWADE" installation.

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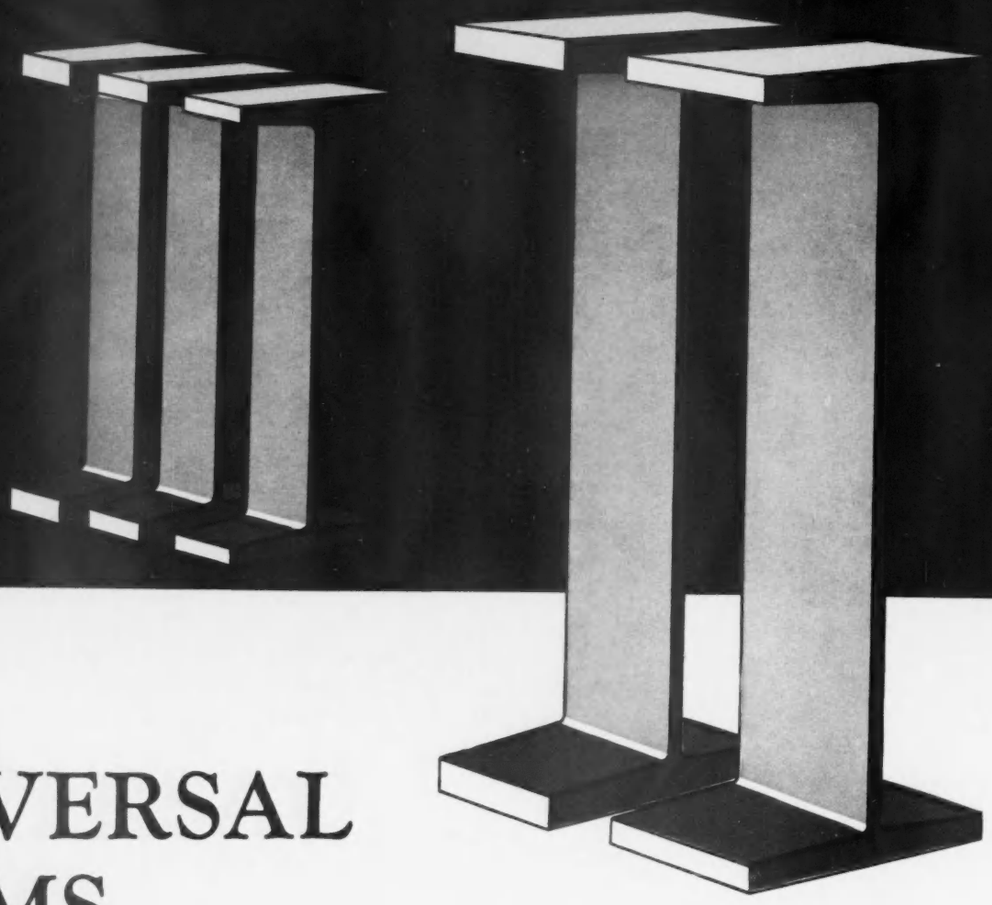

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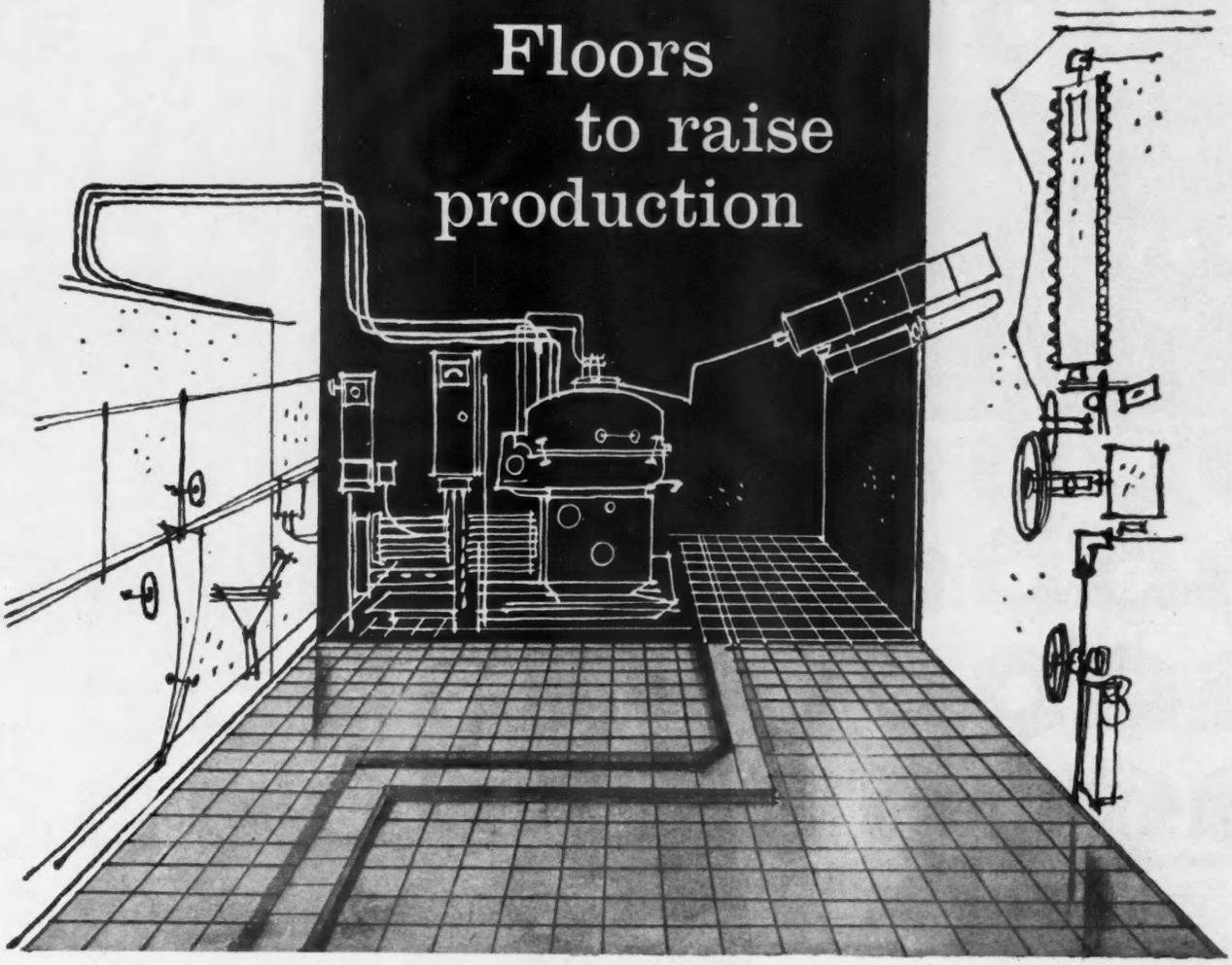
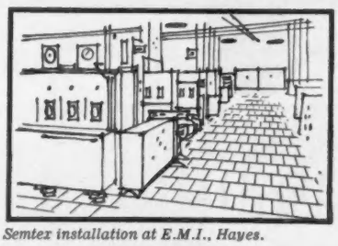
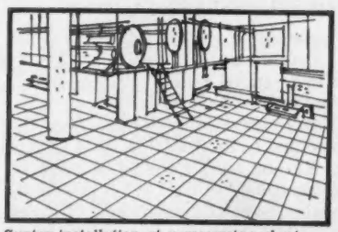




Semtex installation at E.M.I., Hayes.



Semtex installation at a processing plant of the Nestlé Co., Ltd.

A Semtex installation at the Ellesmere Port Refinery of the Shell Chemical Company Limited.

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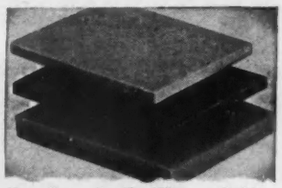

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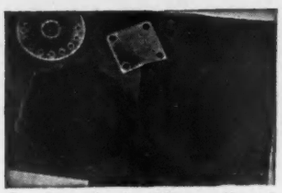

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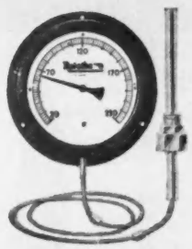

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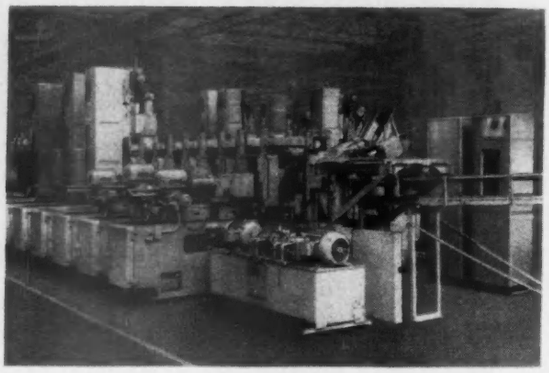

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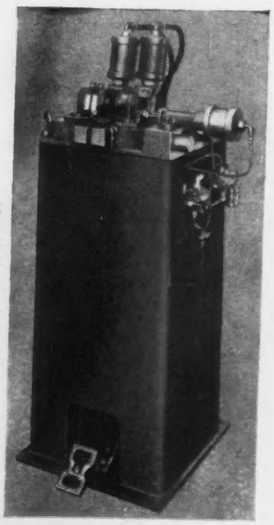

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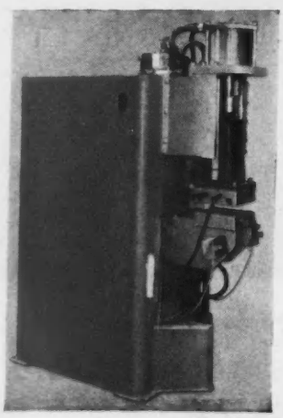

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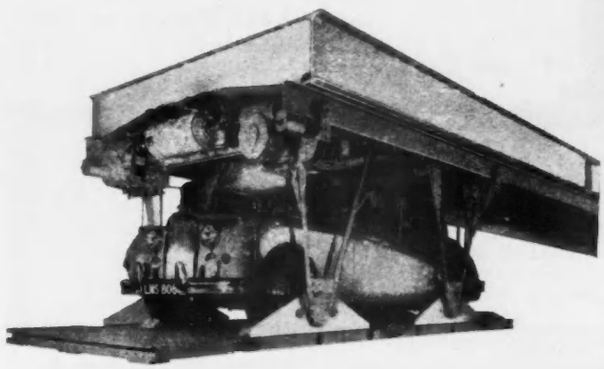

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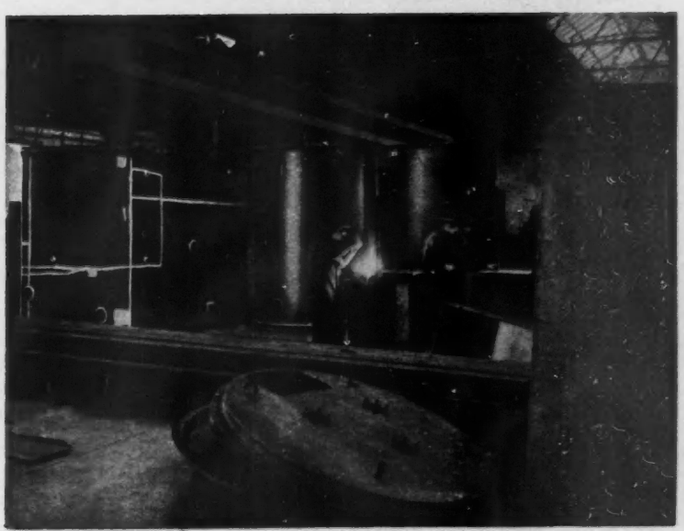

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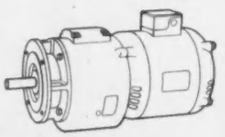

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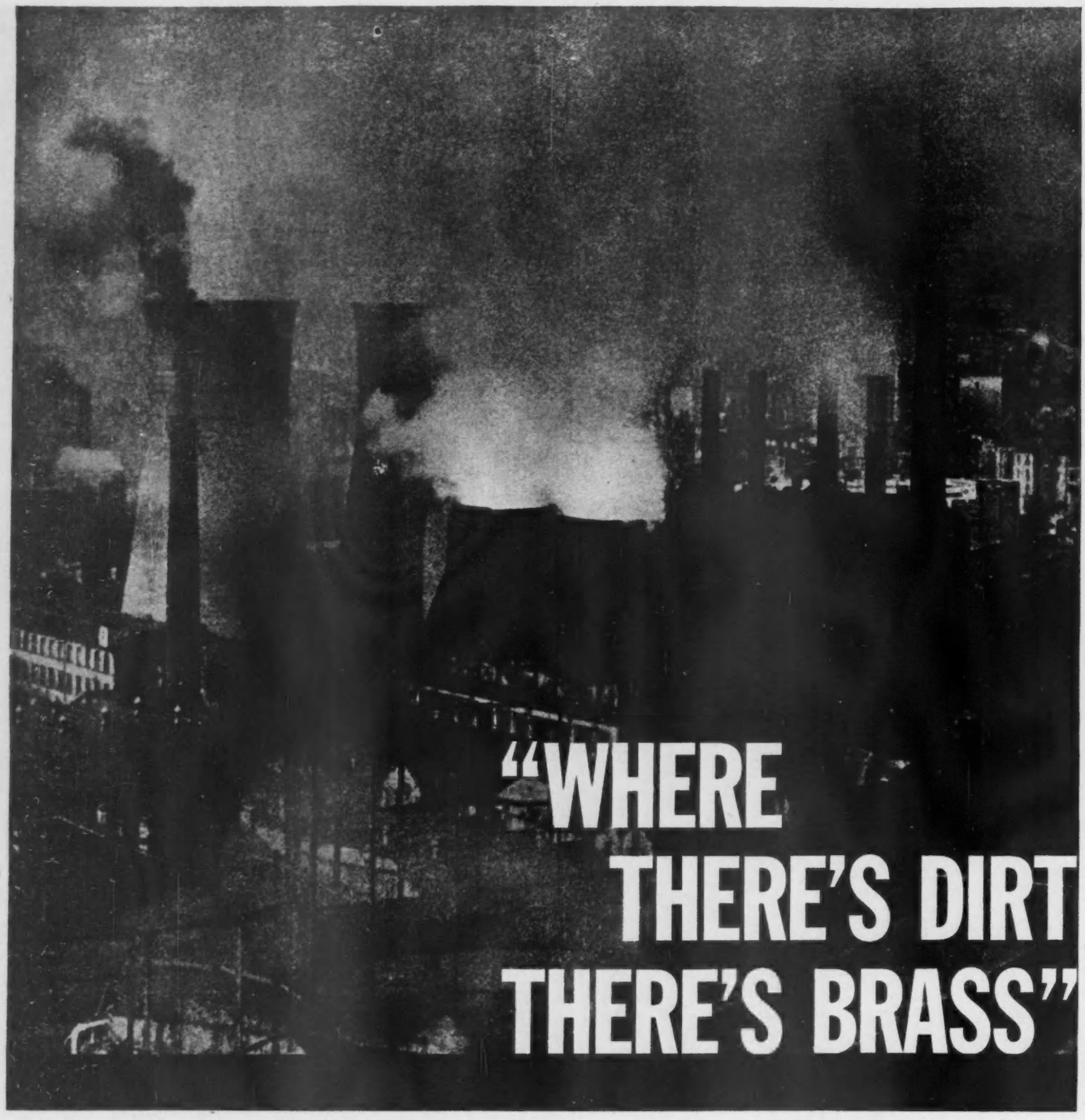

Where there's dirt there's brass was an accepted truth among our grandfathers, but today it is recognised that dirt in any form is the result of inefficiency.

Smoking chimneys mean inefficient combustion. Dust emission from process plants may mean waste of a valuable product. Any fouling of the atmosphere may damage goodwill of neighbours.

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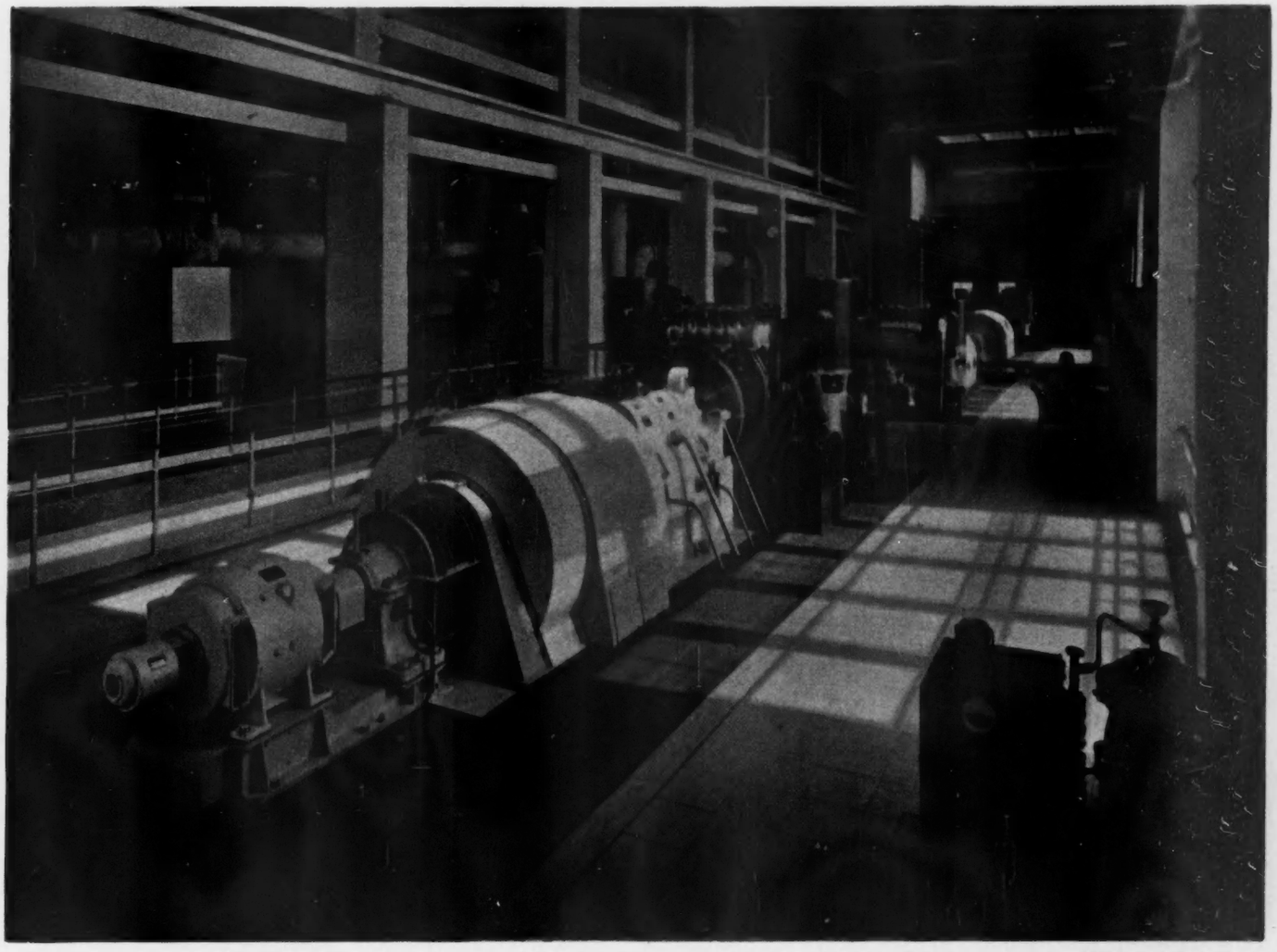

Two 4520 kW Back-pressure, and two 2500 kW Extraction Back-pressure turbine-generators are installed at the Merseyside Power Station of Lever Brothers, Port Sunlight, Ltd.

They are driven by the steam generated for process work and, operating in parallel with the National Grid, provide the electricity for the factory, helping to minimise overall fuel costs.

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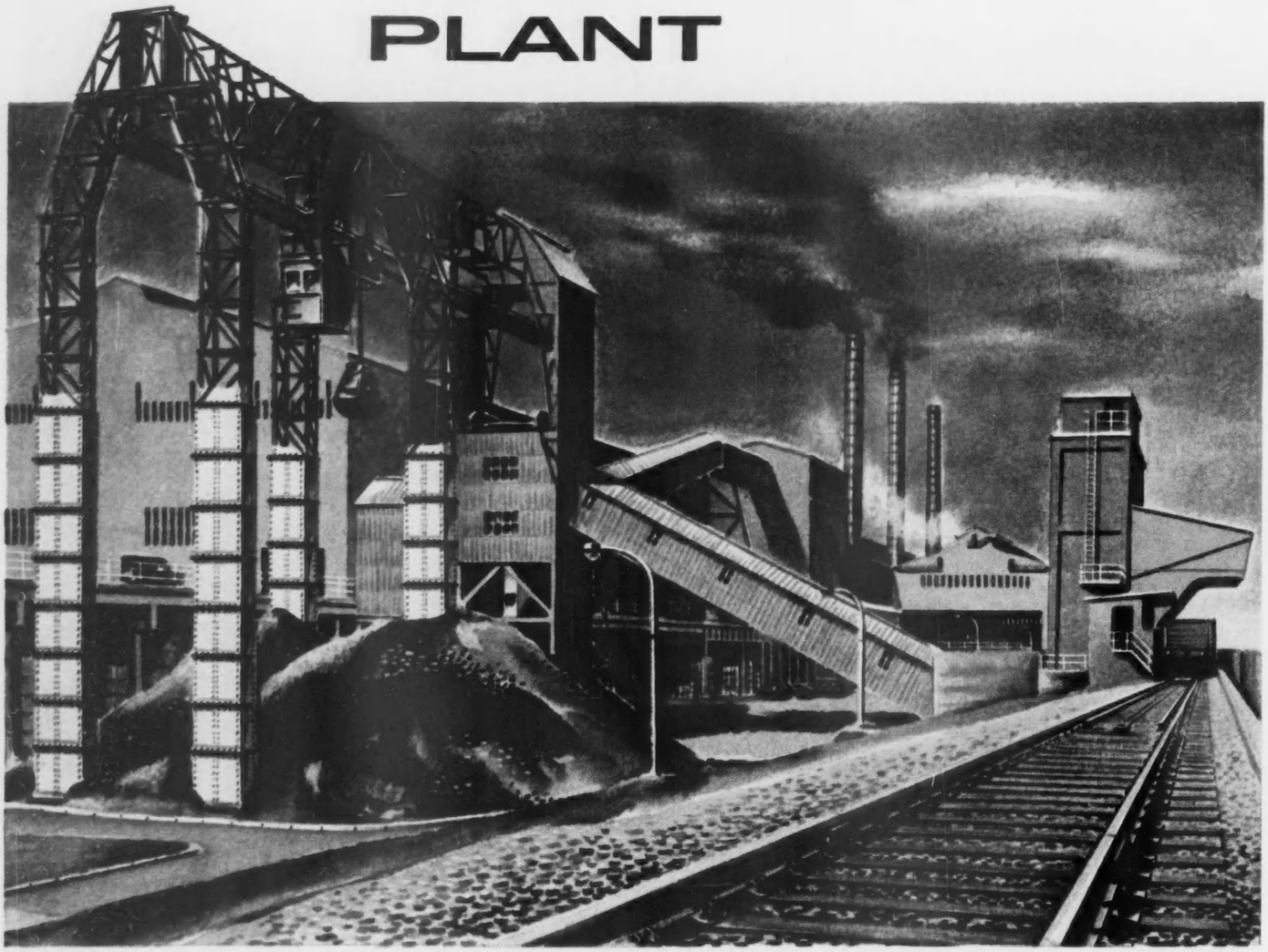

This raw material handling plant at Ravenscraig includes wagon marshalling, a dust trapping tippler, conveyors and a telpher, together with measuring box feeders and pan wagon control.

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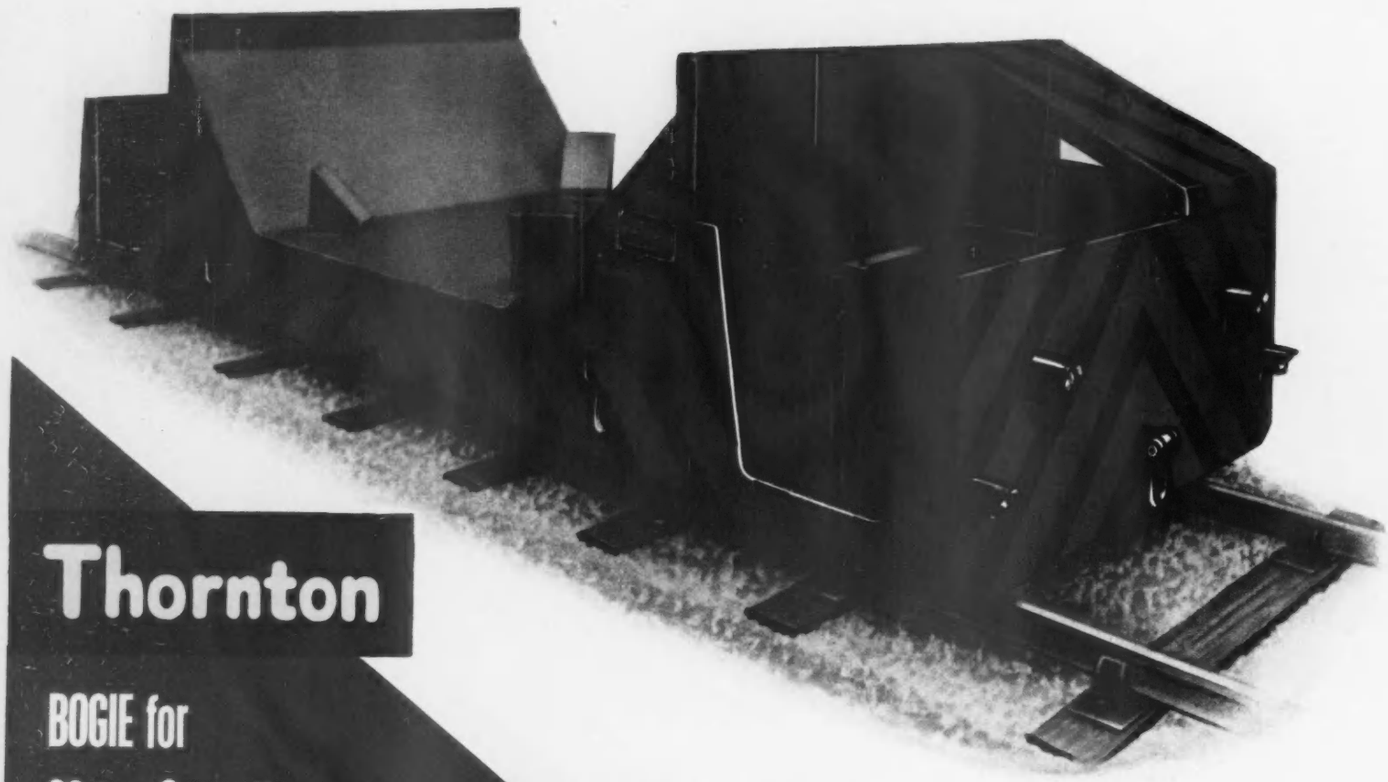

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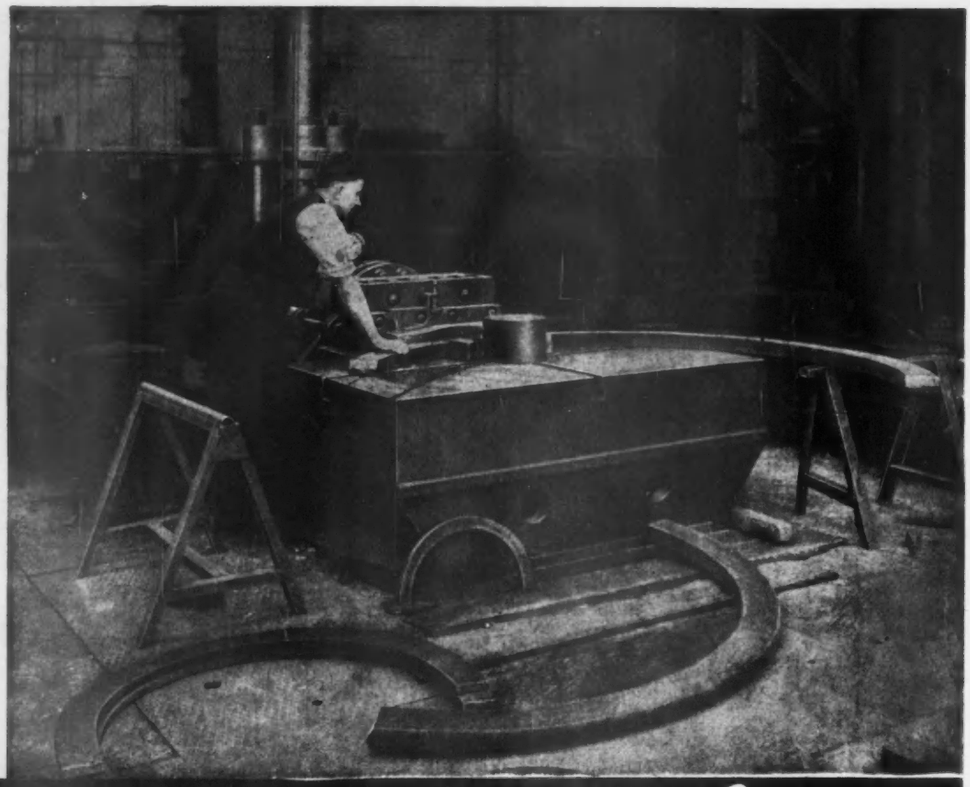

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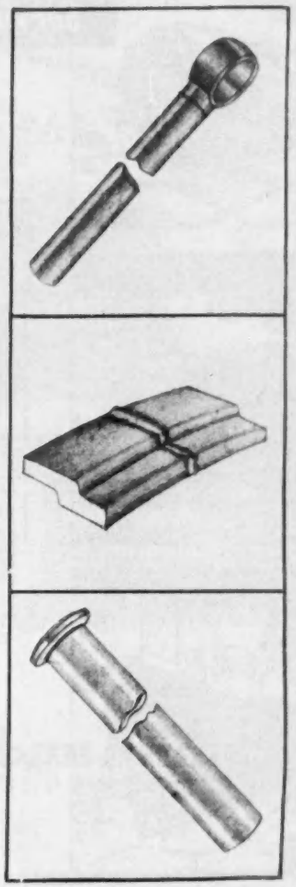

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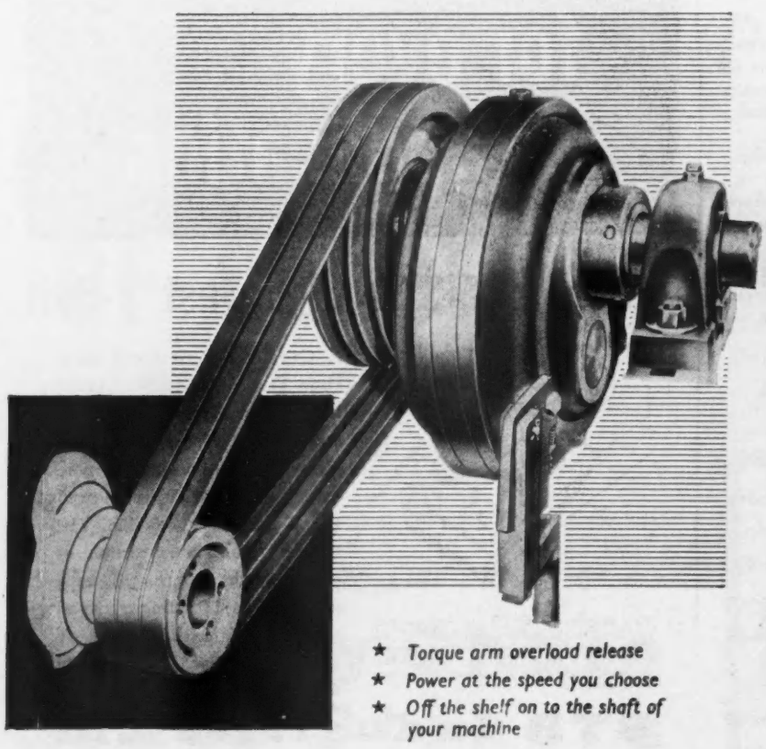

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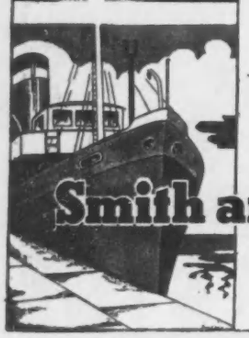

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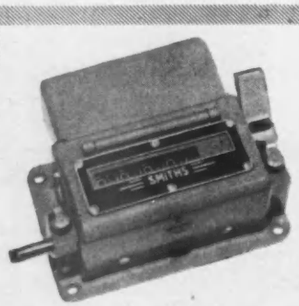

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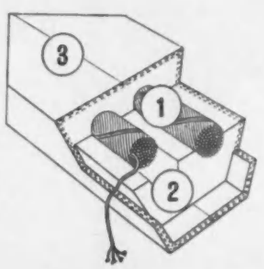

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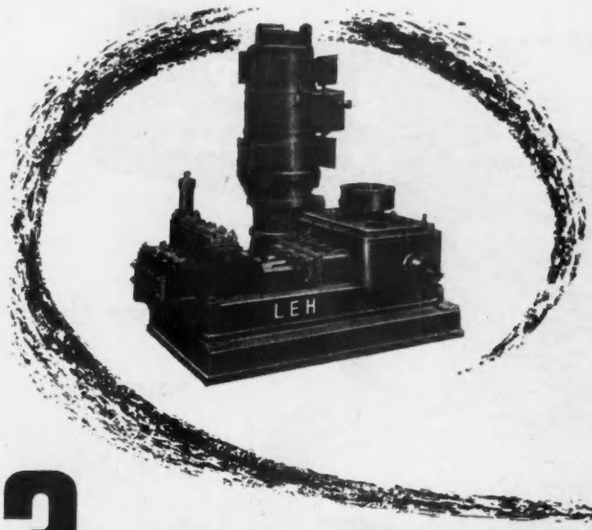

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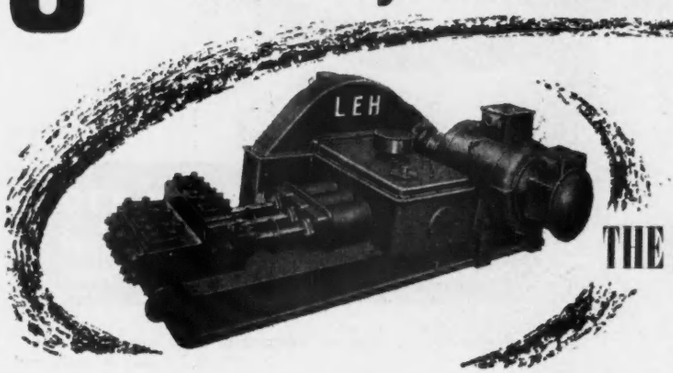

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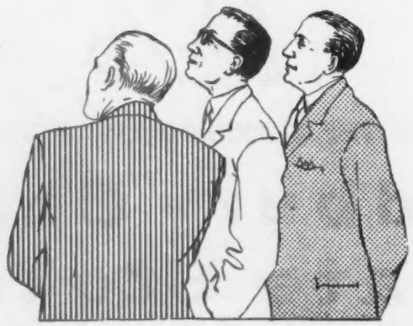

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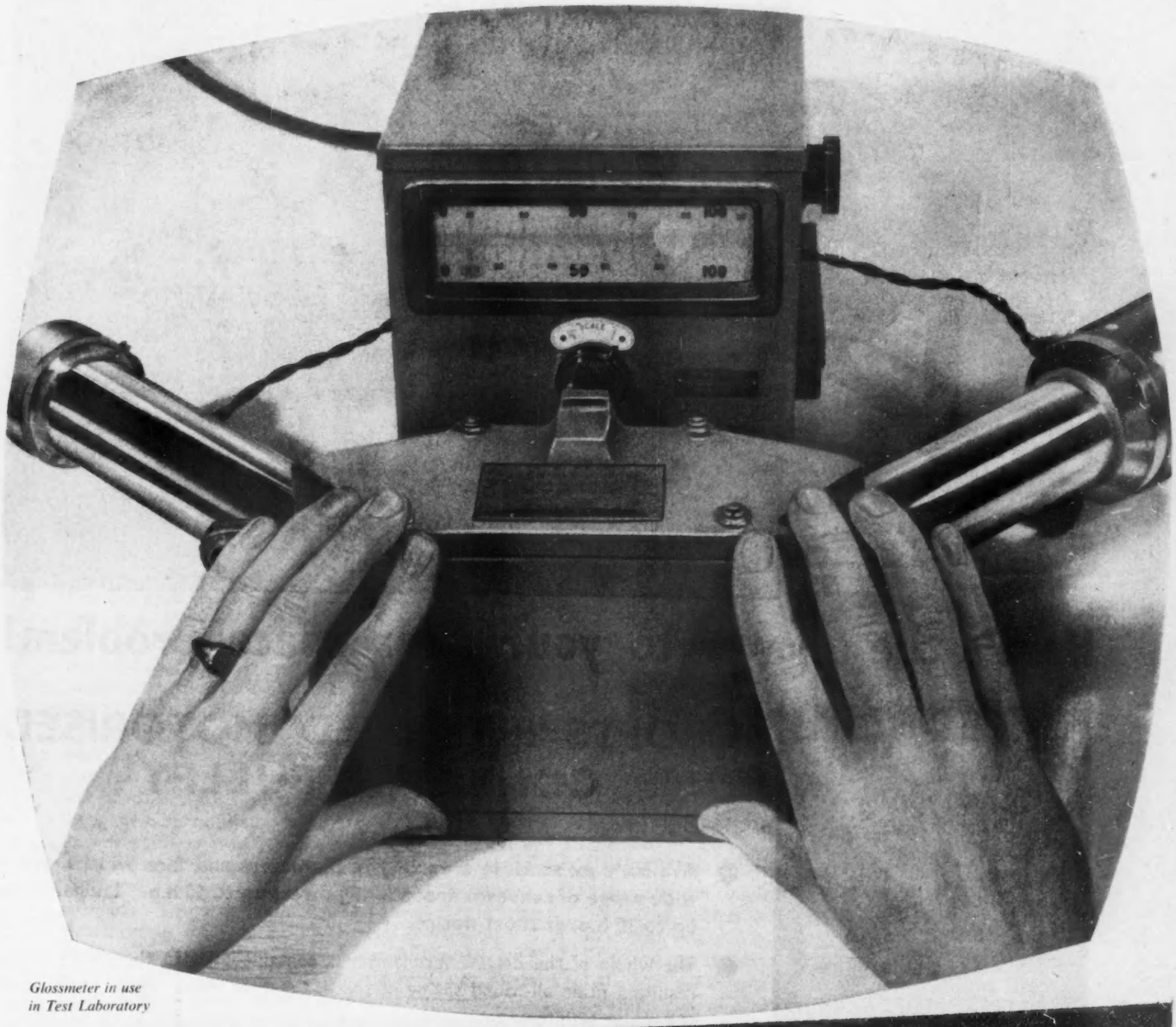

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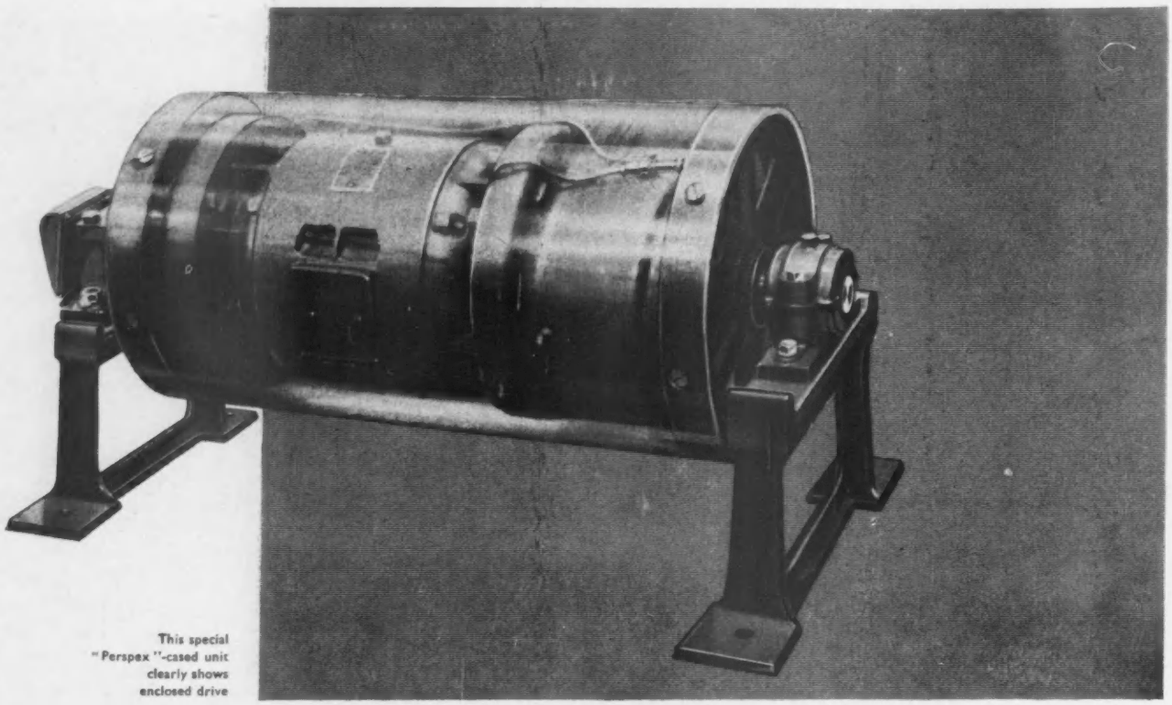

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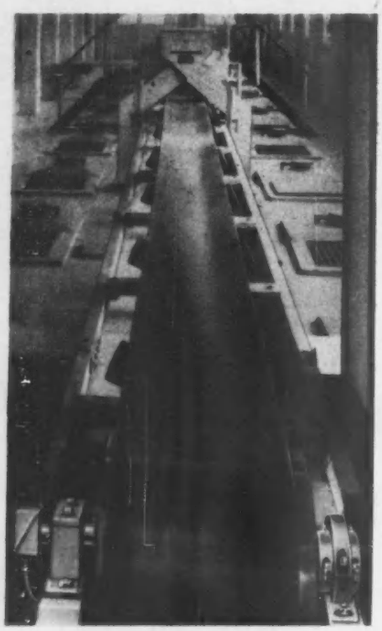

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THE ENGINEER

No. 5435 MARCH 25, 1960 VOL. 209

VERY LAST STEAM LOCOMOTIVE

The building of steam locomotives by British Railways has come to an end. The very last steam locomotive to be built in a British Railways workshop was completed at Swindon and named, appropriately, " Evening Star," on Friday last, March 18. This event foreshadows the end of the steam locomotive era in this country ; for, although it is stated that steam locomotives will possibly still be in service on the railways of this country until the last years of this century, recent events suggest that the end may come more quickly through the closing of lines to traffic upon which aged " steamers " might have survived. There can be very few engineers who did not hear this news with some degree of regret not only because the steam locomotive, probably more than any other work of the engineer, has for long been symbolic of power and mechanical dignity, but also because it has played an outstanding role in the industrial history of this country. Indeed, it can be claimed that the foundations of modern industry in this land and in many other parts of the world were based upon the power of the locomotive to improve transport. Yet, such is the speed of engineering progress, less than a century after its introduction the steam locomotive began to have to face the rivalry of electricity and in a further twenty years it began to be ousted by diesel and electric traction. Now a further, still sadder, step may come to be taken. As recent events have shown, economically the existence of railways themselves is being challenged by road transport. It seems probable that if electrified and modernised they still cannot operate except at a loss in this small island, they will be wholly superseded. If so the wheel will have come full turn. For was it not the coming of the railways which sounded the death knell of horse-drawn road transport in the nineteenth century ?

Since the days of the " Rocket " the development of the steam locomotive has held the fascinated interest of all engineers and a vast band of enthusiasts as well from all walks of life and of all ages. To all of them last Friday's sad announcement must have brought back recollections of many famous locomotives they had seen and of designers they had met or read about. For, wherever the steam locomotive is mentioned, there immediately come to mind the names of such men as Trevithick, Stephenson, Hackworth, Crampton, Gooch, Drummond, Stirling, Gresley, Raven, Churchward, Worsdell, and others still with us, like Stanier, Riddles and Bulleid, to mention only a few of those who played an important part in the development of the locomotive in this country. Although the steam locomotive is now about to pass into history, we feel certain that centuries will pass before details of designs and stories of their achievements will be forgotten. Whatever the future brings, students of traction for many years ahead will learn, not without wonder, of the 102 m.p.h. attained by the " City of Truro " in 1904, and the 126 m.p.h. of the " Mallard " in 1938 ; and feel again in their generation that fever of excitement bred by the race to the north. And there are hosts of other events in the richness of steam locomotive history which the story-tellers of the future, we may be sure, will never allow to be forgotten.

Owing to its relatively low thermal efficiency and availability, the " steamer " has, we suppose, been, in fact, doomed these many years past. But it attained, and still retains for some reason, a degree of interest greater for engineers (as for less technical people) than that which attaches to any other product of the engineer. Neither diesel nor electric locomotives can ever aspire to convey so dramatically to the beholder the sense of unleashed power shown by a steamer on a heavy gradient. Nor do they suggest at speed, as do the steamers, that sense of spirited equine endeavour expressed so aptly by the term " iron horse." Nor should the smaller, rather jolly, little " puff-puffs " encountered on by-lines go unremembered. They had—still have on certain country lines—more character in their valve motion details alone than any diesel railcar can aspire to as a whole ! A feeling of nostalgia afflicts us at last Friday's announcement ; for we fear that modernisation, though very necessary and unavoidable, is taking away from our railways something of dignity, character, and real mechanical beauty which is, in that sense, quite irreplaceable.

INDUSTRIAL DESIGN AND MANCHESTER

The Council of Industrial Design is indefatigable in organising conferences. But seldom can any of them have been favoured by so excellent a contribution as that presented by Mr. W. L. Mather, of Mather and Platt, Ltd., at a Conference on Industrial Design and Textile Machinery on Wednesday of last week at Manchester. It opened with the blunt statements : " Our Manchester area is the largest and ugliest industrial area in the world. . . . It has created a standard of living which should be unacceptable to any progressive nation." Those may be exaggerated notions ; but how really dreadful some of the standards of towns in the North of England are has been and continues to be revealed in all its nakedness by the paintings of T. S. Lowry. Mr. Mather went on to point out that " Emerging nations to-day naturally lay great stress on novelty and appearance and care little for tradition and less for old designs . . . modern appearance and gay colours are part of the new standard of living " ; and he stressed the need to travel abroad to see what is going on in other countries and the ease with which, through modern air travel, ideas can now be exchanged between nations that formerly had little influence upon one another. The need to see how others live is, he thinks, all the more important because visual standards in the Manchester area are so low.

All these preliminary remarks seemed to us to express sound sense. We liked, too, Mr. Mather's quite trenchant criticism of undue secrecy between competing manufacturers at home. " Too much secrecy is far more dangerous than too little," he said, " It breeds a defensive and restrictive outlook and often destroys the initiative and imagination upon which progress depends." But the

part of Mr. Mather's address in which we were especially interested related to the training of designers. The universities, we think, should give particular attention to it ; for in the context of design, Mr. Mather had nothing whatever to say about them—nothing whatever ! It is to someone with a broad education drawing little distinction between arts and sciences and certainly not specialising in either that he looks for good design. For training in design he likes to select a boy in his late 'teens, naturally artistic in mind and good at free-hand drawing ; and he feels that " more budding artists " ought to be encouraged to enter the engineering profession. The boy so chosen should have a year or so on the drawing-board and a couple of years in the works " to learn practical engineering." During the whole time he should attend day release and evening classes. Finally, he ought to attend a course in industrial design such as is provided at Salford School of Art in conjunction with Salford (Peel Park) Technical College. " Coming from the drab industrial background, these industrial design courses are an eye-opener to the average student who has been brought up to accept functionalism and ugliness as natural to industry. Consciously to make utilitarian equipment beautiful is a new conception ! "

Maybe, of course, Mr. Mather was thinking, in selecting and training a youngster for industrial design, of something rather different from engineering design. Yet he remarks : " This approach can stimulate the type of design mind we need, particularly if there is an early integration of industrial design with technical studies " ; and, again, " I consider that all trainee engineers should have some knowledge of industrial design even if they are not subsequently concerned with design." The obvious point about the kind of training which Mr. Mather recommends is that it is consciously striving to stimulate the creative instincts of those who experience it. By contrast, a university education in engineering is apparently intended to stimulate only analytical and critical powers. Both types of mind are needed in industry and, fortunately, creativeness can survive the assault of a university course. But need there be any question of survival ? Cannot the creative as well as the critical faculties be stimulated at a university ?

ROAD SIGNAL CONTROL

Road users tend to remember delays at traffic lights rather than the occasions when the lights have saved them time by opening a way into a traffic stream. This habit of mind deprives the road signal engineer of some of the public esteem which he might expect, and when general concern with traffic problems leads to discussion of what might be done with electronics, or even computers, the work he has done already in this country is likely to be overlooked. This specialised subject has now become of general interest, as shown by the review of current practice given to the Institution of Highway Engineers by Mr. E. Thorpe of the Automatic Telephone and Electric Company, Ltd., and summarised in our issue of March 18. Progress from fixed time control of traffic signals to vehicle-actuation, and on to the so-called " linked " or " progressive " systems, had taken place before the second world war. Vehicle-actuation brought the need for varying right-of-way times according to traffic demands, and hence required timing circuits responsive to signals derived from vehicles passing over detectors in the road. These circuits at first incorporated neon tubes but in recent years have changed to thermionic valves. The conception of " area control," of which something has been heard since the Minister of Transport's visit to the United States, is derived from co-ordinated control of signals as in the installation at Trafalgar Square in 1933 by the Automatic Telephone and Electric Company, Ltd., while others were brought into operation two years later by The Siemens and General Electric Railway Signal Company, Ltd., in the Kensington, Marylebone and Holborn areas. In such systems vehicle-actuated signals are subject to an over-riding control so that main road traffic proceeding through the area at a certain speed is subject to minimum delay. Adjustment of the signal cycles according to traffic flows is implicit in schemes of this kind, the conditions modifying the impulses sent out to the various signal locations by the master controller. Electronics may well provide more convenient means of collecting, storing and transmitting information than the conventional detector mats, relays and uniselectors, but the final result would be the same and should not be regarded as a new approach to traffic control problems.

New methods are constantly under review by the Ministry of Transport, the Road Research Laboratory and the signal engineering firms. Some developments may pass unnoticed by the road user although he benefits from their effects. There are now numbers of sites in various parts of the country where " variable minimum green " has been introduced. A useful experiment last summer was in the use of portable vehicle-actuated signals where road repairs require single-line traffic. Fixed-time control in these circumstances is a frequent source of irritation, and the use of a normal vehicle-counter tube on the road surface for transmitting " demands " to a controller shows promise of being able to smooth the progress of holiday motorists at many bottlenecks. The use of computers for traffic problems is in some minds, including those of computer manufacturers. As far as the road signal engineer is concerned, he knows the information he requires for controlling his signals and appears satisfied at the moment that he has the means of obtaining it, although continuously alive to all possibilities of improving his techniques.

IMPACT OF MOTORWAYS ON CITIES

On March 15, a joint meeting of the Institution of Civil Engineers and the Royal Institute of British Architects was held to discuss the problem of motorways within the large centres of population. Mr. Rowland Nicholas, the city engineer of Manchester, presented the first short paper, whose title we have used for this note, which was a characteristically factual analysis. The second paper, " Impact of Motorways on the Urban Environment," by Mr. Frederick Gibberd, dwelled on the architect's attitude to motorways in large towns, and the wider effect of such roads on town planning, and " urban sprawl." Both papers are excellent expositions, and well worth reading. We were particularly struck by the wide difference of approach used respectively by engineer and architect, yet by the close concordance between them in the broad conclusions they reached. It was also satisfying that these same conclusions concur with the arguments we have stressed quite often over the past few years, when this subject has been discussed in our " leader " columns.

Some reservation must be made, however, to explain Mr. Gibberd's attitude. The architect believes, he says, that the motorway is a fundamental part of the equipment of an industrial society ; but " when the motorway enters the built-up area the architect loses his enthusiasm." " The term urban motorway," he goes on, " is a contradiction in terms and no motorway should penetrate an urban area unless all other alternatives have been examined and found wanting." This last condition he clearly accepts, though not explicitly, in subsequent arguments

which relate town-planning to roads—the all-purpose road is defunct, he says, and " roads are one part of the town's organism, and their design is subservient to town-planning." In other words, the architect would rather have a town without motor vehicles ; but since he cannot, he will plan to segregate the motor vehicle to carriageways " exclusively for moving traffic," leaving the life of the town and its architectural groupings largely unimpeded. An excellent concept ! The basic objection of the architect to the motorway in a town is that it is " destructive to the physical environment," completely severs one area from another, and its huge scale and function " make it impossible to associate with groups of buildings." American examples are obviously in mind here, and also the great motorway down the centre of Caracas, which Mr. Gibberd calls the " Grand Canyon." But then he himself goes a long way towards the solution of his own problem. Clearly this country stands to benefit from American mistakes, and to be in a position " to build these roads so that they may be elegant as well as useful " —this last quotation being from Mr. Nicholas ! It would be interesting to inquire whether this same attitude is held by architects, or ever was held, about urban railways, which are a fairly close parallel. Or whether the common spectacle of heavy traffic flowing through a shopping centre, the latter served by only narrow pavements, is considered more or less destructive of the æsthetic urban scene than the motorway ?

Mr. Gibberd's point that the needs of the pedestrian tend to be ignored in planning surveys is, of course, very pertinent. " Traffic surveys," he says, " require a complementary survey into pedestrian flow." This point might well have been brought out in the House of Commons on March 11 last, when the subject of traffic engineering was debated. Members seemed to assume that the movement of vehicles on roads was the only subject with which a traffic engineer is concerned ; in fact, flows of people, or goods, are equally open to his observation and analysis. Yet it is an encouraging sign of the times that such a subject should be discussed at all in the House of Commons, and an indication of the awareness that is felt for this central problem of road traffic, its economic flow, and the accidents due to it, a problem which is, above all, a problem of the large towns. Other events, too, show the attention which is being given to its solution. At the Institution of Civil Engineers last week, for instance, an exhibition on " Car Parking " was opened, at which innumerable ingenious ways of packing cars into buildings, or into " open spaces " slightly modified, can be seen. And next week the traffic engineering study group of the Institution of Civil Engineers is to discuss parking, when Mr. Nicholas will again be speaking. All of this activity is laudable, in view of the urgency of the problems which are behind it, but the only real progress will be made " on the ground " in the building of urban motorways and relating them to urban development as a whole.

LONDON ASSOCIATION OF ENGINEERS

Last Friday evening we were reminded that a hundred years ago there were regularly reported in these columns the monthly meetings of the London Association of Foremen Engineers. Those meetings were held on Saturday evenings in the City, the membership of the Association, which was founded in 1852, comprising foremen and managers of London engineering businesses. Prior to the formation of the association, foremen had but little opportunity to get together to discuss the technical problems that arose in their various works and they were the people upon whom there rested a great deal of the responsibility of the successful running of a works. The Association's second president, a Mr. Joseph Newton, who reigned for twenty years, described them, in fact, as " the ruling active spirits who convert the rude materials, which are the bases of the ingenious machinery which distinguishes England above other nations, into the finished and scientifically arranged rods, levers, wheels and appliances which make up the substance of all mechanical arrangements ! " From the outset, it was determined that the Association should be technical and social ; all discussion of the politics of the engineering industry were strictly forbidden. At the age of 108, this association is still very much alive. The " Foremen " has been dropped from its title and for some years it has been known as the London Association of Engineers. The principal qualification of full membership is that a candidate shall have been in an executive position in a London engineering concern, large or small, for at least three years. The Association still meets regularly once a month on a Saturday evening, which alone is no mean achievement in this age of a five-day week ! The papers presented for discussion deal with all kinds of engineering topics of the moment. Effectively, it seems to us, there is a blending of tradition and modern requirement. Moreover, as was demonstrated at the 108th annual dinner which we had the pleasure of attending last Friday, the Association is keen to encourage youth. A pleasant event in the evening's programme was the presentation of prizes to three apprentices who are this year's winners of a junior challenge shield competition.

The Engineer—100 Years Ago (MARCH 23, 1860)

" FOREIGN AND COLONIAL JOTTINGS "

" The Administrative Council of the Italian Railway have announced that the 12th section, viz., from Martigny to Sion, will be opened on the 18th of May next. The first section, between Bouveret and Martigny, has been in operation since the 14th of July last. The Italian line to continue the Paris and Lyons and the Geneva Railways as far as Arona, forms an important part of the great line from Paris to Milan, by way of the Simplon.—Sebastopol remains as at the period subsequent to the siege, in a very dilapidated state. A few ruins had been reconstructed into habitable dwellings for the soldiery, but nothing more in the shape of renovation. Some Jews have settled in the place and employ their time in picking up bullets and shot from the vast area to the south and east of the city. An American company has raised forty of the sunken ships from the entrance channel.—The keel of a new iron-sheathed line-of-battle ship is about to be laid down at Cherbourg. She will be 328 ft. in length, with an iron prow 30 ft. long, and be called the Napoleon I.—The iron-sheathed frigate La Normandie, built at Cherbourg, is about to be launched. Theiron-plates with which she is covered weigh more than 1,000 tons, which is the burden of a first-class merchant ship. Beneath the iron is a covering of teak wood. The frigate is to be armed with thirty-six rifled cannon of large calibre. When armed her total weight will be 6,000 tons.—Spanish sulphur seems likely to become a formidable rival to that of Sicily. A discovery made at Huelva (Andalusia), by a French engineer, of veins of ore which had been worked in the times of the Romans seems likely to change the face of that poor district."

Automobile Braking

In the sixth Crompton-Lanchester lecture, delivered on March 16, 1960, at a meeting of the Automobile Division of the Institution of Mechanical Engineers, Dr. R. C. Parker presented a survey of automobile braking which is given in abstract below. Comparison of disc and drum brakes on the simplest basis of equal areas and volumes of metal facing the friction elements, and assuming equally favourable cooling conditions, shows the disc to run cooler than the drum only after repeated applications have raised the temperature considerably. The need for adequate brake cooling is reiterated.*

THE general principles involved in decelerating a vehicle will be first examined, after which a knowledge of the stresses imposed on any brake system will be sought from an examination of the consequences of the various patterns of driving behaviour.

The single braked wheel has been examined by the Road Research Laboratory during their study of road surfaces. Measurement was made of the braking force coefficient and slip when the former was defined as the friction force developed in the plane of a brake towed wheel divided by the normal load, and the latter as the percentage difference in the rotational speed of the braked to the freely rotating wheel. Fig. 1

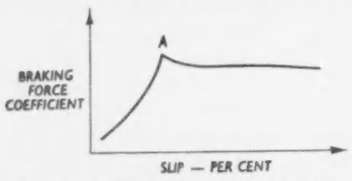


Fig. 1—Relationship between braking force coefficient and slip

shows the type of relationship found between the two quantities for smooth tyres. Increase of the retarding couple from zero causes some slip, and up to a critical region *A* both quantities increase in a uniform manner. The curve beyond *A* shows that further increase in the retarding couple gives increasing slip with no further increase, or even a reduction, in the braking force coefficient. Up to *A* the shape of the curve depends upon the deformation characteristics of the tyre and wheel, but beyond *A* the braking force coefficient depends only upon the friction between the tyre and the road. At *A* the wheel is said to enter the skidding condition, and this being a region of instability, slip tends to increase rapidly. At 100 per cent slip the wheel is fully locked and the peripheral (friction) force equals the product of μ and W where μ is the coefficient of sliding friction between the tyre and road, and W is the normal load ; in this limiting condition μ is often referred to as the coefficient of adhesion.

The maximum value of the braking thrust required from any braking system will be governed by the value of the friction force and as this cannot exceed $\mu \times W$, a knowledge of these two quantities under all conditions is needed before the maximum braking thrust can be specified.

Coefficient of Adhesion

The braking force coefficient mainly depends upon the nature of the road surface, the tread pattern, and the hardness of the tyre rubber.

Much of the data on the coefficient of adhesion has been obtained with smooth tyres and relates to a sideways force coefficient at a speed of 30 m.p.h. This coefficient has been found to be numerically equal to the braking force coefficient for smooth tyres and is obtained by measuring the restoring couple when the plane of a freely rotating wheel mounted on a sidecar arrangement is inclined to the direction of travel. On smooth, fine-grained road surfaces the patterned tyres gave a marked increase in the braking force coefficient up to a sideways force coefficient of 0·6, but for greater values the smooth tyres gave the better results. For coarse texture surfaces the smooth tyres gave rather better results throughout than did those with patterned treads.

The sideways force coefficients measured on the various types of road surfaces in all conditions, yield values from 0·05 for melting ice to 0·9 for dry macadam. Whilst patterned tyre treads even out some of the differences between rough and smooth roads, nevertheless, widely varying values of μ do occur.

A brake designer must thus make provision for a maximum value of 0·9 and since μ may fall to 0·2 under wet conditions at high speed, or even to 0·05 for ice, it is clear that any automobile braking system must enable full utilisation to be made of any existing value of the road-tyre adhesion.

Adhesive Weight

The maximum braking force occurs when a wheel is near to or in the locked position. Unless, however, the braking force achieves parity with the product of the normal load and coefficient of adhesion at each wheel simultaneously, any attempt to lock all wheels may merely result in loss of control through premature locking of one wheel. The behaviour of a car with the various wheels locked is such that although the lateral deviation of a car is more severe with locked rear wheels than front, the latter is to be avoided since it is accompanied by complete loss of control over the steering.

The forces acting when a car is braked on a level road cause a decrease in the magnitude of the vertical reaction through the rear wheels, and a similar increase in the front of magnitude.

Since the retardation will be at maximum when all wheels lock simultaneously, the ratio of the braking force on the front wheels to that on the rear ones should be equal to the ratio of the transferred weight which is termed the braking ratio.

TABLE I—*Effect of a Fixed Brake Ratio on the Deceleration Obtainable on Different Surfaces*

Coefficient of adhesion, μ	Actual to maximum braking, per cent	
	Braking ratio 72/28	Braking ratio 60/40
	I	II
0·9	86·5 } Rear-wheels lock	71 }
0·8	91·5 }	74·5 }
0·65	100 Maximum	80·5 } Rear-wheels lock
0·50	91·5 }	87 }
0·30	83·5 }	97·5 }
0·26	81 } Front-wheels lock	100 Maximum
0·20	79 }	96·5 } Front-wheels lock
0·05	73·5 }	89 }

Table I shows, for popular medium-sized cars, by how much the deceleration falls from the maximum on different road surfaces and with two values of the brake ratio. The actual brake ratio on this car is 60/40 and, while full advantage cannot therefore be taken of the best road surfaces, this ratio lessens the chance of front wheel slides. These figures refer to an unladen car ; for most cars the centre of gravity moves aft with passengers and luggage and this has the effect of decreasing the front to rear ratio and so moves the position of the maximum in column II higher up the table.

Brake Usage

Various patterns of brake usage dictate the stresses imposed on a brake system and should constitute the data on which a brake rating is based. This would then fulfil the requirement that for economic development a vehicle should be designed to withstand only those conditions that it may encounter in service.

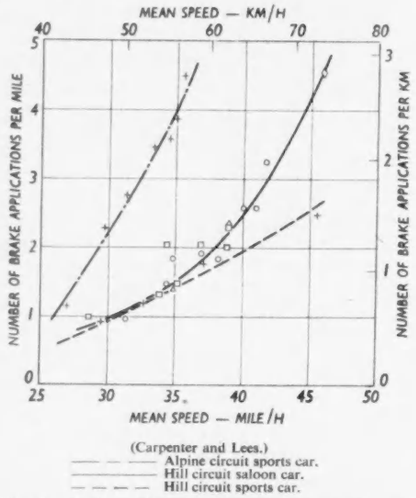


Fig. 2—Number of brake applications per mile and per kilometre against speed

The only work seemingly published on the subject of brake usage is that due to Carpenter[1] and Carpenter and Lees,[2] who investigated a number of the more important variables. Patterns of brake behaviour were established for two 2-litre cars of laden weights 32 cwt and 23 cwt, when run on country, hill, and mountain circuits.

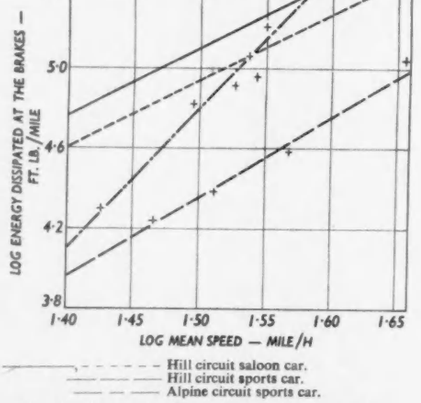


Fig. 3—Energy dissipated at the brakes against speed

The effect of mean speed, the driver, the terrain and weight of car are shown in Figs. 2 and 3 from Carpenter and Lees.[2] Whereas the energy dissipated by the brakes was dependent upon the driver, the mean rate of

* Director of Research, Ferodo, Ltd.

working at the brakes was not, apparently, due to the fact that associated with the lower gear is a shorter braking time. It should be noted that four times as much energy was dissipated by the brakes with a 50 per cent heavier car. The steep line for the sports car on the Alpine circuit shows that an increase in the mean speed produces a much sharper increase in the rate of work done on the brakes than was the case on the hill circuit. A further point of interest is that increase in mean journey speed is achieved at the expense of free running time or brake cooling time.

On the hill circuit the mean rate of work generally lies below 40 b.h.p. whilst the highest mean rate recorded is 114 b.h.p. which compares with a figure of 100 b.h.p. for the maximum of the engine. Again whilst the energy dissipated at the brakes is generally less than 20×10^4ft lb, a figure as high as 140×10^4ft lb was reached.

The saloon car on the hill circuit made some 3000 braking applications in 1400 miles, and the frequency varied from one stop per mile for a mean journey speed of 30 m.p.h. to one and a half per mile for 35 m.p.h. For the sports car on the Alpine circuit the corresponding figures were two and four brake applications per mile respectively.

The Alpine circuit was characterised by sections of varying severity, and unpublished figures by Carpenter show that the most severe duty was imposed when motoring down the Susten Pass at a mean journey speed of 36 m.p.h. when there were forty-seven brake applications in 6·44 minutes, giving an average of twelve per mile. Data obtained in a competitor's car in the 1959 Monte Carlo rally showed that over a distance of 2000 miles 6·8 applications were made per mile and the brakes were applied for 9·9 per cent of the journey time. The mean journey speed was 37·6 m.p.h. Over two sections, Figéac to St. Fleur and Chambéry to Monaco, the applications per mile were 10·2 and 10·5 respectively, and a maximum brake lining temperature was recorded of 644 deg. Fah. Though no measure of the level of deceleration was taken on the Monte Carlo car, in the case of the saloon car on the hill circuit a deceleration of $0\cdot5\,g$ was never attained and most applications were below $0\cdot2\,g$. These figures for deceleration are similar to those given by Starks[3] in rural and built-up areas. The average number of brake applications was two per mile and 80 per cent of the brake applications were less than $0\cdot2\,g$, a deceleration of $0\cdot4\,g$ was exceeded only five times in the 2500 braking applications measured.

Newcomb[4] used Carpenter's data for the Susten Pass when the maximum energy dissipated in a single stop was 183,000ft lb, and the total dissipation was 2×10^6ft lb and specified an equivalent "fade test" comprising twelve brake applications from 46 m.p.h. to rest at a deceleration of $0\cdot5\,g$ at thirty-second intervals. Each brake application in this test dissipates an amount of energy equal to the maximum encountered during the descent of the Pass, whilst the total energy and time are equivalent. While it may be agreed that the car weight of 2600 lb is too light, there is some doubt as to whether a heavier car could maintain the same average speed. Had a mean speed of 40 m.p.h. been adopted, Newcomb shows that the initial speed in the equivalent fade test would have to be raised to 57 m.p.h. The 57 m.p.h. test would seem adequate to cover all conditions that are likely to be met with on the roads in Europe.

Brakes and Braking Systems

In selecting a brake with a brake shoe factor (the drum drag/shoe-tip effort) matched to the correct combination of the pedal ratio and hydraulic ratio, care must be taken not to employ too great a shoe factor since this will be accompanied by an undesirable sensitiveness, for at high values of shoe factor the brake becomes very sensitive to small changes in coefficient of friction.

The general topic of sensitivity is difficult to treat on account of the difficulty of selection of basic assumptions. For example, $d\mu/\mu$ has been selected as the primary variable but there is no evidence to suggest that loss of friction during fade is related to the friction level itself, and $d\mu$ is an equally acceptable quantity. Secondly, departures from the nominal value of shoe factor may arise from shoe flexibility, distortions, drum inaccuracy, wrong positioning of lining, bad brake adjustment, presence of road dirt, water, oil, &c., and probably a number of other causes. None of these are easy to stipulate in mathematical terms so that analyses that have been made of brake sensitivity are probably best regarded as a general guide.

The various disc brakes currently employed can be divided into three classes :

(1) Axially floating discs and fixed caliper.
(2) Fixed discs and axially floating caliper.
(3) Fixed discs and fixed caliper.

The first has been largely abandoned, while the third is gaining universal acceptance since it offers the best possibility of maintaining a steady pressure between the disc and the pad. The major problem in disc brake development has been the design of a caliper since it may have to withstand a load of some 4000 lb without undue flexing.

From the work of Newcomb,[4] it is clear that disc brakes do not run at sensibly lower temperatures than do drum brakes. Their functional advantage is that high temperatures cause the disc to expand and so obviate the need for a high ratio of pad to pedal travel. This virtue enables them to be run hotter. The disc brake may thus be said to have encouraged the evolution of friction material clearly capable of withstanding higher temperatures, and this has been possible because the absence of curvature in the linings has made less stringent demands upon the organic bonding agent. The disc brake is open to foreign matter which, under adverse conditions, might cause scoring or corrosion of the disc and rapid wear of the pads. Should shrouding of the disc prove necessary, then temperatures could easily rise above the limiting value imposed by the materials used.

Brake Drums, Brake Discs and Brake Linings.—It is these three components that largely determine the duty which a brake may carry. Mechanical stresses may cause the bore of a brake drum to go out of round and flare, and whilst the open ends usually become enlarged it can happen that the open end of a bimetallic drum decreases in diameter. Not only do distortions worsen as the temperature rises during braking, but a brake lining may run against a hot drum long enough to wear to an increased radius, so that when subsequently applied against a cool drum, the lining makes contact only at its extremities. This change will not only alter the brake shoe factor, but if associated with an eccentric drum can give rise to a periodic torque pulse which, if near to the resonant frequency of the suspension unit, may cause roughness or even judder during braking. Similarly, great care must be paid to the design of brake shoes, for not only can the degree of rigidity affect the distribution of pressure and hence the shoe factor, but deflections across the shoe width can confine the work done to narrow strips on the drum surface which become overheated. In addition to the mechanical stresses, there arise high thermal stresses due to the steep temperature gradients that exist near the rubbing path surface immediately the brakes are applied. These thermal stresses can cause surface fatigue and sometimes complete fracture of the drum. Brake drums are still in the main made from close-grained pearlitic cast iron with a total carbon content varying within the range 3·0 to 3·5 per cent, and combined carbon ranging from 0·5 to 0·8 per cent. Alloying elements are also widely used, as exampled in millenite and chromidium cast iron. With bimetallic drums it is essential that their potential advantage with respect to limiting temperature be gained or else their greater coefficient of expansion may cause too much pedal travel. The users of bimetallic drums have paid particular attention to the important matter of cooling. Several designs in the racing field have utilised a drum as an integral part of the wheel and this, combined with various devices for forcing the air over the circumference of the drum, has eliminated high temperatures and consequent loss of pedal travel due to drum expansion. Brake discs are now usually made from chromium cast iron or pearlitic malleable iron and a top-hat shape of disc has proved efficacious in preventing the more severe types of distortion.

Brake linings comprise a mixture of organic and inorganic materials whose relative volumes may cover the wide range of 1/2 to 2/1. The main inorganic constituent is asbestos, used either as a fibre or woven into cloth ; among the organic materials which bind together the inorganic constituents more emphasis is latterly placed on synthetic resins such as the simple phenolic formaldehyde resols and oil-modified phenolic resins.

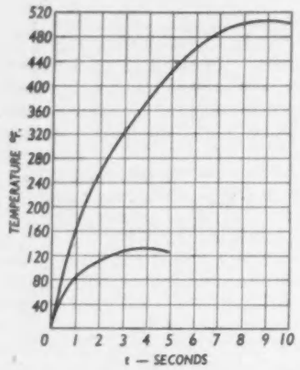
Brake Rating

A knowledge of the possible combinations of brake type and brake diameter for a given retardation must be augmented by information on the capacity of the component parts to withstand usage. Their effects are those concerned with repeated absorption of energy, and the ability of a brake to withstand such treatment is termed its rating.

Two such ratings are the ratio of the gross vehicle weight to the area of the lining, and the horsepower dissipated per square inch of the lining area, but none has been justified on theoretical grounds.

The important manifestation of absorption and dissipation of energy by a brake is temperature, and a brake rating factor can only be of value in so far as it will determine this quantity.

The calculation of drum and disc brake temperatures is not in itself sufficient to derive a brake rating, but Newcomb[4] has shown that consideration of temperature, in association with information on brake usage, enables the designer to select a brake that is unlikely to exceed a specified temperature. Dealing with drums or discs of finite thickness, Newcomb provides a solution for the transient temperatures that may arise in a complete or partial brake application, either on the level or down an incline, and similarly provides a solution for the average temperature obtained at the end of a stop. A treatment is next presented to cover convection cooling when further analysis gives the formula that corresponds to brake applications repeated at regular intervals.



Thermal conductivity, $K=0{\cdot}007\ 39$ B.Th.U. $feet^{-1}s^{-1}$ deg. $Fah.^{-1}$.
Specific heat, $c=0{\cdot}11$ B.Th.U. $pound^{-1}$ deg. $Fah.^{-1}$.
Thermal diffusivity, $\alpha=0{\cdot}000\ 16 ft^2\ s^{-1}$.
All energy dissipated at drums.

Fig. 4—Temperature rise at interface of a front drum and lining at any instant during a five-second application from 30 m.p.h. to rest, and a ten-second application from 60 m.p.h. to rest using a cast iron drum

In Figs. 4 and 5 are shown two curves from Newcomb's paper but with actual temperatures shown on the ordinates corresponding to the medium-sized car mentioned earlier. It should be noted in passing that both these curves were subject to experimental verification, and gave agreement to within 10 per cent. Combining the formulæ for the repeated and transient case gives a formula similar to that derived by Odier[8] for infinitely thick drums, and enables the limiting temperature to be expressed in terms of the required design constants, that is,

$$\theta_s-\theta=\frac{\sigma y P u^2}{1{\cdot}002\times10^5 A_1}\left(\frac{1}{ht_0}+\frac{0{\cdot}0217}{d}\right) \quad . \quad (1)$$

where $\theta_s-\theta$ denotes the amount in degrees Fahrenheit by which the temperature of the rubbing surface is above the temperature of the air circulating round the cast iron drum, σ is the proportion of total heat entering the drum, y is the braking ratio, P the vehicle weight in pounds, u the initial velocity in feet per second for repeated braking, A_1 the area in square feet of the brake path, h the

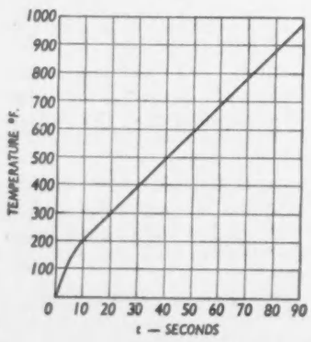
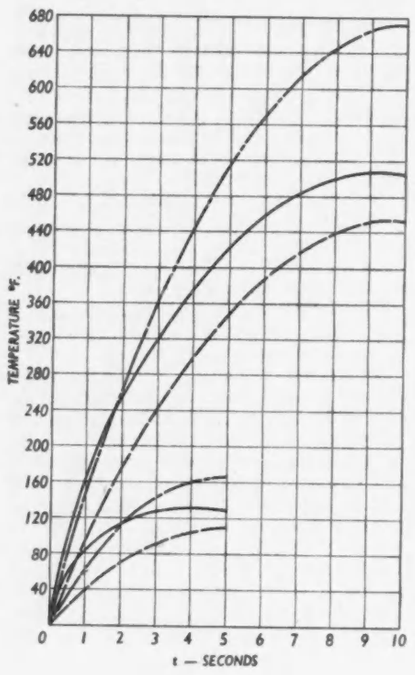


Fig. 5—Temperature rise at interface of a front drum and lining with time when continuously braking at a constant speed of 30 m.p.h. down a gradient 1 in 10 for 0·75 mile

coefficient of heat transfer B.Th.U. per square foot per second, t_0 is the interval between repeated brake applications in seconds, and d the drum thickness in feet. The value of σ varies within the range 90 to 95 per cent for conventional materials, but h can vary widely and consequently is of great importance. For a ventilated drum h varies as $v^{0{\cdot}6}$ but for a shrouded drum it is virtually independent of speed. Though the use of a thicker drum will reduce the temperature rise for a single application, it will also increase thermal stresses and the practical range lies between $\frac{3}{16}$in and $\frac{5}{16}$in. These studies are based on the assumption that surface temperature gradients do not arise from large differences between the real and apparent contact areas either by reason of distortion or uneven expansion; an assumption which is valid if the correct combination of drum materials and friction materials are employed.

The use of the Newcomb formula first demands a decision on the limiting temperature for either the proposed fade test mentioned earlier or else a fade test based on other known brake usage. The limiting temperature will



Thermal Properties of Drum

	Copper	Cast iron	Aluminium
K, B.Th.U. ft^{-1} s^{-1} deg. $Fah.^{-1}$	0·0625	0·007 39	0·0323
c, B.Th.U. lb^{-1} deg. $Fah.^{-1}$	0·0914	0·11	0·206
α, ft^2s^{-1}	0·001 22	0·000 16	0·000 93

No energy loss during braking.

Fig. 6—Temperature rise at interface of a front drum and lining at any instant during a five-second application from 30 m.p.h. and a ten-second application from 60 m.p.h. using aluminium, cast iron, and copper drums of the same dimensions

depend upon the materials employed for the drum or disc and friction material with due consideration being given to the problem of thermal stresses. By substitution of the appropriate values for σ, y, P, u, h, t_0 and d the limiting value of A_1 can be calculated. The area of the brake path of the preferred brake arrangement can be compared with A_1 and, if too small, then either the width of the brake path can be increased or else the diameter. The latter is usually fixed, so a drum can only be increased in width, but here the possibility of shoe and drum distortion gives a limit of about 3in. Should no increase in drum or disc be acceptable, the remaining solutions are either to increase h by using wire wheels or forced ventilation, or to employ drums or friction materials with higher limiting temperatures.

A comparison of equation (1) with the horsepower per square inch rating for a car of 2600 lb weight, shows that whereas both treatments yield the same order of result for speeds of 46 m.p.h., the former gives a value for A_1 65 per cent greater than the horsepower rating at 60 m.p.h.

Fig. 6 emphasises the value of materials with high thermal capacity and conductivity for reducing the interface temperature for brake applications of short duration. Fig. 7 shows that the cast iron drum will run at a slightly lower, and the bimetallic drum of equivalent weight and having the same h value, at an appreciably lower, average temperature than will a disc over a single brake application. However, since a disc has a greater area exposed to the atmosphere, increased cooling gives the disc brake a slight advantage with respect to temperature for repeated applications. These curves relate to a drum $\frac{1}{4}$in thick and a disc $\frac{1}{2}$in thick. If a $\frac{1}{2}$in thick drum is replaced by a $\frac{3}{8}$in thick disc, then the disc will run hotter than the drum for both single and repeated applications.

Brake Assessment

A braking system will be accepted for production only after rigorous testing.

Test programmes differ widely but a common fault is to introduce stresses that are alien to service conditions in the hope that a correct diagnosis of likely troubles

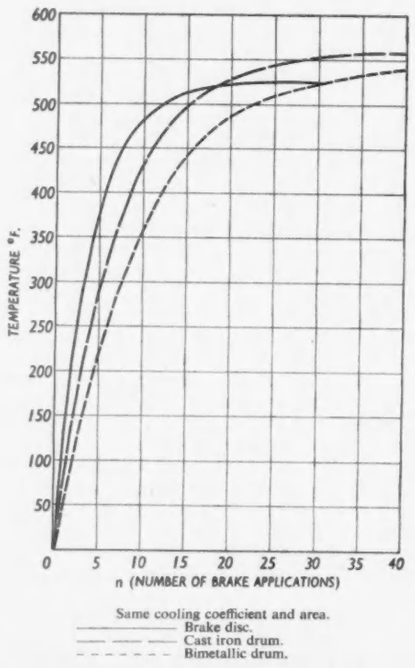


Fig. 7—Comparison of temperature rise of a cast iron drum of thickness 0·25in; bimetallic drum of equivalent weight and a brake disc of thickness 0·5in, during regular repeated brake applications from 30 m.p.h. to rest in five seconds at a frequency of braking 2 per minute

can be obtained in a short time. It would seem sensible to place more emphasis on field tests designed to discover which components are likely to fail under normal motoring conditions. The importance of such an approach is emphasised by work carried out in 1952 during a safety week in Salford, which showed that 28 per cent of the cars examined had practically no braking on one or more wheels, while an earlier survey showed that 12 per cent of the cars examined at random could not obtain a deceleration of more than 0·4 g.

Conclusions

The list of topics which have had to be omitted is long, and an incomplete picture is no foundation on which to forecast the future, yet should this be shaped by technical requirements, two long outstanding needs should be emphasised. The first is that the minimum stopping distance on all road surfaces can never be achieved without automatic selection of the correct front to rear brake ratio. The second is that the single factor of greatest importance in brake design is adequate brake cooling; indeed, given this, many of to-day's problems would disappear irrespective of what type of brake is employed.

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Theory of Machines

A SUBJECT ABANDONED AT SOUTHAMPTON

By C. H. HELMER, B.Sc.(Eng.), A.M.I.Mech.E., University of Southampton

FOR a little more than half a century the term "Theory of Machines" has been used to designate one of the main subjects of study for students of engineering. It began to be used in the examinations of the Institution of Civil Engineers in 1904. This was followed by its use as a sub-title of Jamieson's seventh edition of *Applied Mechanics* in 1910,* and as the title of a book by McKay in 1915. Since then there has appeared a succession of books bearing this title, two of them as recently as 1954 and 1955. It has also been used in the Associate Membership examinations of the Institution of Mechanical Engineers since their inception in 1913* and is still in use both there and in University courses for Mechanical Engineers.

An examination of the text books bearing this title shows that there is a fairly uniform understanding of the scope of the subject. There is reason to think that a number of examination syllabuses follow much the same pattern. After an introduction of basic mechanics we find the kinematic analysis of mechanisms, usually restricted to those lying in a plane, and based on specific mechanisms rather than on general principles. This part has not changed materially during the period under review. The last of the books alluded to above does not refrain from parading those old veterans, valve diagrams for steam reciprocating engines!

The dynamics of the reciprocating engine comes in for a detailed study, with turning-moment diagrams, flywheels and inertia loads on connecting rods and bearings. The balancing of engines usually gets a chapter to itself and in some cases includes the necessarily heavy-going treatment of the Vee and radial engine and even our old friend, the railway steam locomotive.

The centrifugal governor also receives close attention, first the different forms with gravity control—museum pieces indeed—then those with spring control and a brief mention of the inertia governor. It should be noted that all this is concerned only with the governor as a speed or acceleration sensitive device. The fact that in use it is only part of a larger system, the whole of which must be taken into account before the suitability of the governor can be assessed, is not mentioned.

After these we come to a variety of devices, belt drives, brakes, dynamometers and clutches, grouped together because their analysis involves that unpredictable phenomenon, dry friction, and other equally doubtful premises. Gear trains and gear tooth forms are also dealt with, the latter aspect sometimes in great detail, although nowadays only a very few specialists require it. Most engineers needing toothed gears obtain them from manufacturing concerns specialising in their production.

That very important topic, vibration, has gradually found a place in the last chapters of the later books on Theory of Machines, but rather as an afterthought.

It was against this background that plans were made, several years ago, for the corresponding part of the degree course for mechanical and aeronautical engineers at Southampton University. The guiding principles kept in mind were to provide (1) a course related to current practice and developments in this particular field; (2) a course with a connected and logical treatment—in other words a worthwhile academic discipline. The result, perhaps rather revolutionary, was the abandonment of the traditional subject Theory of Machines.

In its place there is, for second year students, a course with the main headings, balancing, vibrations and control systems. The subject of balancing is retained and placed first because of its importance in almost every field and because out-of-balance is the cause of many cases of undesirable forced vibration. The treatment given to it is brief, but sufficient to show the principles, and does not go beyond the case of "in line" reciprocating engines.

Vibration of linear systems occupies nearly half the course. The natural and forced oscillations of systems giving rise to a second order equation are dealt with at some length with prominence given to vector methods. The view is taken that a student who gains a good understanding of the behaviour of such systems is well equipped not only to deal with many of the vibration problems he is likely to meet but also to go further in this subject should he so require. Included in this is a section on the response of recording instruments and other apparatus, the choice of instruments for particular uses, and also a comparison between instruments responsive to displacement, velocity or acceleration. Undamped systems with two degrees of freedom, coupling and gears are also included. Parallel with this a number of graphical exercises are set, such as harmonic analysis, frequency of vibration of a typical linkage and an introduction to the phase-plane method for non-linear systems. These are followed by suitable laboratory work on vibrations.

The remainder of the course is an introduction to the theory of control systems, particularly servo-mechanisms, the basic theory of which follows very easily on the earlier topic of vibration. Here the unifying character of this subject is displayed by the inclusion of a number of topics formerly appearing as rather disconnected items in Theory of Machines but all employed in the field of servo-mechanisms. Thus after a discussion of hydraulic relays, their uses and limitations, the spring-controlled centrifugal governor is briefly introduced as a speed-sensitive device and then considered in association with the whole engine—governor—relay—fuel-valve system. This is an excellent example of a closed-sequence control system which has long been known both in practice and theory, and deserves to be more widely understood.

The principles of gyro-instruments can, in a second-year course, be taken only as far as the steady state of precession, but this is sufficient to introduce the spring-controlled gyro as a rate measuring device as used in numerous servo-mechanisms. Gear trains too fit in well, simple and epicyclic trains as part of the transmission system and the differential gear as a mechanical error-sensing unit.

It should be mentioned that certain topics—general mechanics, velocity and acceleration diagrams, elements of gear-tooth forms, simple flywheel and friction problems, including belts and pulleys—have already been dealt with in the first year of the course. A more advanced treatment of control system theory, gyro-systems and other topics is given to honours students in the third year.

Some readers will no doubt find fault because of the disappearance of some topics formerly considered essential. It is contended that they were of lesser teaching value, too specialised or, by reason of the changing practice of engineering, they no longer have the importance they formerly had. Their place has been taken by other matters more abreast of current requirements, selected and arranged to give an integrated course and prominence to general principles rather than particular machine parts and suitable for development later at a more advanced level.

* The writer is indebted to the Librarian of the Institution of Mechanical Engineers for this information.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

TWIST DRILLS

No. 328 : 1959. Part 1. Price 15s. This specification has been revised to incorporate work done in recent years on the international standardisation of twist drills and it contains dimensional tables for jobber, stub and long series twist drills and for Morse taper shank drills and core drills. All the tables are fully in accordance with (draft) I.S.O. Recommendations for these types of tools.

Common flute and overall lengths ensure that drills in any one size range have the same general dimensions whether made in the inch or metric system of measurement. These lengths have been arrived at after very full discussion at international level and the aim has been not merely to establish a logical series of increments but also to provide the lengths which should prove most efficient and economical in use. A comprehensive table gives the flute and overall lengths of all standard sizes of different types of drills.

DOUBLE CIRCULAR ARC TYPE GEARS

No. 978 : Part 2 : 1952. Addendum No. 1 (1959). Price 3s. This addendum to Part 2 of B.S.978, which was published in 1952, gives details of the basic rack tooth shape and a range of metric modules from 0·15mm to 0·70mm. It specifies limits of error for the principal elements of each gear and for the centre distance of mating gears. There are particulars also of the form and basic dimensions of suitable cutters for the manufacture of pinions with from six to twelve teeth.

Composition and Structure of Plastics

By DR. R. BEECHING

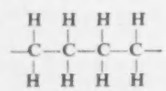
The James Forrest lecture was given last Tuesday at the Institution of Civil Engineers by Dr. R. Beeching, who is development director and technical director of Imperial Chemical Industries, Ltd. The lecture was entitled "Plastics in Engineering," and its introductory section, describing the nature and classification of plastics materials, is printed here. The full lecture went on to discuss, in broad terms, the mechanical properties of plastics and their uses and applications in the world of engineering.

TO the best of my knowledge, nobody has succeeded in presenting plastics in their proper perspective as engineering materials, nor am I sure that it is possible to do so. On the other hand I have been convinced for many years that engineers are prevented from employing plastics to full advantage, not by any lack of detailed information about their properties, but by lack of a general, simple, appreciation of how the materials may be expected to behave in practice and for what kind of purpose their use may reasonably be considered.

Plastics are materials composed of very large molecules built up by an aggregation of a great number of simpler molecules of one kind, or of very few different kinds, arranged in a repeating pattern. These macro-molecules are commonly referred to as polymers, although it is not strictly accurate to do so in all cases. Some of them occur in natural substances, such as hair, horn, rubber, gutta-percha, balata, silk and cotton, as well as in other natural tissues, fibres, gums, and resins. To a growing extent, over the last half-century, new macro-molecular substances have been synthesised, to form the group of solids which we describe as plastics, as well as synthetic rubbers, fibres, films, paints and varnishes, and glues. The boundary lines which divide plastics from rubbers, glues, fibres, and films are not very clear, because often the same polymers, or variants of them, appear in more than one form. In general, however, when we speak of plastics we think of semi-rigid to rigid solids, and recognise fibres and films to be rather specialised forms of some of these same materials.

All this becomes clearer if we start considering examples, and the easiest example with which to start, although not historically the first of the synthetic polymers, is polythene.

Ethylene is an unsaturated hydrocarbon gas of composition $CH_2=CH_2$. Under the right conditions, and in the presence of a suitable catalyst, a whole series of ethylene molecules can be made to jam together, because of the spare valency band of each carbon atom, to give long chain-line molecules



These chains may grow to several hundreds or thousands of carbon atoms in length, according to the conditions of reaction, and the resulting products may range from oily liquids, through waxes, to the horny solid familiar as polythene plastic.

Polythene, a truly polymeric material, is the simplest of the class of materials known as thermoplastics—a name which implies that the materials to which it relates may be reversibly and repeatedly rendered plastic by heating, as opposed to the other main class of materials, the thermosetting plastics, which are non-reversibly plasticised and set by heating.

Although the earliest of the synthetic plastics were thermosetting materials, the thermoplastics have now become the more important class and are still growing in output much faster than the older group. Most of the materials in this class may be regarded as modifications of polythene, thus :

Name	Polymer
Polythene...	$-CH_2-CH_2-CH_2-CH_2-$
Polypropylene ...	$-CH_2-CH(CH_3)-CH_2-CH(CH_3)-$
Polyvinyl chloride (P.V.C.)	$-CH_2-CH(Cl)-CH_2-CH(Cl)-$
Polymethylmethacrylate	$-CH_2-C(CH_3)(COOCH_3)-CH_2-CH(COOCH_3)-$
Polystyrene	$-CH_2-CH(C_6H_5)-CH_2-CH(C_6H_5)-$
Polytetrafluoroethylene (P.T.F.E.)	$-CF_2-CF_2-CF_2-CF_2-$
Nylon	$-CH_2-CH_2-C(=O)-NH-CH_2-CH_2-$ and $-CH_2-CH_2-CH_2-CH_2-C(=O)-NH-CH_2-CH_2-$

All these polymers can grow as long chains, although under some conditions of formation they have a tendency to branch, and the resulting molecules may be regarded as behaving like springy flexible fibres, with some tendency to crimp or coil. In the solid plastic they will be aggregated together with varying degrees of random entanglement and ordered packing.

If the molecules do not attract each other very strongly along their length, any tendency which they have to crimp or coil will assert itself and their normal state will resemble a mass of loosely tangled springs. When stressed they will stretch readily, and snap back on release with typical rubber-like behaviour. If the attractions between molecules at points along their length are greater, or if the molecules themselves are stiffer, the polymer will have greater rigidity. If heavily stressed, the molecules will still uncoil to some extent, but the resulting strain will disappear only slowly when the stress is released because the molecules do not have the same freedom to recover their equilibrium degree of coiling.

If the attraction between molecules is sufficient, and if their geometry is such as to favour regular parallel packing, there will be regions of crystallisation, with intermediate amorphous regions. In the crystalline regions, bundles of molecules will be linked together much more stiffly than in the amorphous regions, with the result that, with increasing crystallisation, polymers tend to become more rigid—stronger with less deformation before fracture.

Molecules of any of these three types tend to orientate when the polymer is stretched, because the molecules are extended in the direction of the stress, and tend to become parallel to it. This orientation may itself encourage crystallisation, but is not the same phenomenon. Sometimes at room temperature, as in the case of polythene or nylon, or at rather higher temperature in the case of "Terylene," polymers can be made to undergo almost complete orientation, by drawing them to several times their original length. The adiabatic heating which occurs on drawing, followed by rapid cooling, sets the fibres in a greatly extended and highly oriented state. This is how the synthetic fibres are given their very high strength, because the orientation of the molecules parallel with the fibre axis causes them all to make their maximum contribution to the bearing of an axial stress.

Having in mind this picture of the various ways in which polymer molecules may aggregate, we can combine it with knowledge of the chemical structures of some of the thermoplastics and see how structure affects properties. For the most part, this is a process of explaining known properties in terms of structure, and there is only a limited element of prediction involved, but consideration of the relationship between structure and properties does help to give insight into the way in which polymers behave and may also help to reduce the confusion of types.

Because of its paraffinic nature, polythene is chemically rather inert, and the absence of electrical polarisation in the molecule makes it a first-class insulator. Because of the irregularity and simplicity of their structure, unbranched chains crystallise readily, by regular parallel packing, to give a mixed crystalline/amorphous structure. As the temperature is raised, the amorphous content causes the polymer to soften over a fairly wide temperature range, and then the crystalline regions cause it to melt rather sharply if the temperature is raised still further. The degree of crystallisation is very much affected by the branching of chains, and this is influenced by the conditions under which the polymer is formed. The close packing associated with crystallisation raises the density of the polymer. If the molecular weight and chain length are low, the polymer is relatively fluid, and tensile strength, elongation to fracture, stiffness and resistance to impact all increase with increase in molecular weight. Crystallisation further increases tensile strength and stiffness, but reduces toughness.

Polypropylene, the next in the series as set out above, is very similar to polythene in many respects, but the molecular configuration of the unbranched chains is such that it crystallises more strongly than polythene, with the result that it is stiffer, has a higher tensile strength, higher softening range and higher melting point.

The structural difference between polythene and polyvinyl chloride is the replacement of every fourth hydrogen atom by the much larger and more electro-negative chlorine atom. This has the effect of distorting the chains so that they cannot pack

regularly, but also has the effect of stiffening each chain due to the electrical forces along its length. As a result, P.V.C. is a stiffer, stronger material than polythene. Due to the absence of crystallisation it has no sharp melting point and has a relatively low softening range. It has poorer dielectric properties than polythene because of the variation of electric charges over the molecule. Chemically it is fairly inert, but is dissolved by some organic liquids.

Polymethyl methacrylate, like P.V.C., does not crystallise and has rather similar mechanical properties. It softens progressively with increase in temperature. Chemically, it is fairly inert and it has fairly good properties as an insulant. Among its outstanding properties are its extreme transparency over the visible spectrum and also its resistance to weathering.

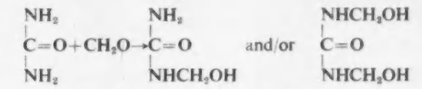
In polystyrene, the presence of a large benzene ring attached to every second carbon atom in the chain makes the chains themselves very stiff, and the material is relatively hard, rigid, and brittle. It has a water-white transparency, and also has excellent electrical properties. It is the one plastic which has a metallic ring when struck, due, no doubt, to the absence of hysterisis under high frequency cyclical stressing, because of the stiffness of the molecules.

The next polymer, polytetrafluoroethylene, could almost equally well have been placed next to ethylene in the series, because it resembles it closely in some respects, though quite different in others. In P.T.F.E., all the hydrogen atoms in ethylene are replaced by fluorine. Because these fluorine atoms bond so strongly to carbon, the polymer is one of quite exceptional inertness, being attacked only by molten alkali metals and by fluorine. Like polythene, because of the regularity and simplicity of the chain structure, P.T.F.E. crystallises readily and strongly and has mechanical properties like a slightly stiff polythene. Because of its high degree of crystallinity, and the close packing of the chains, it has higher density than other plastics and also has an exceptionally high softening point. One very valuable and interesting consequence of the extreme chemical inertness of the molecule is the exceptionally low coefficient of friction of the material, the coefficient for P.T.F.E. on itself is lower than that for ice on ice.

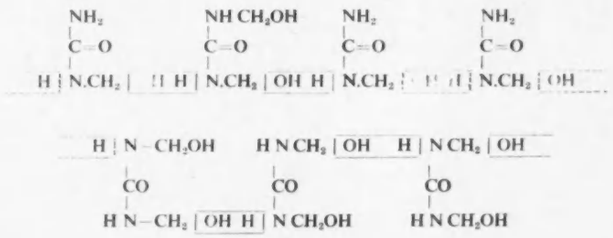
The last of the polymers listed is not quite a member of the same series as the others, because, in nylon, the continuous carbon backbone which characterises them is interrupted at intervals by a different linkage involving a group $-\overset{\overset{O}{\|}}{C}-\overset{\overset{H}{|}}{N}-$. This chemical difference need not concern us greatly, however, because, in its broad characteristics, nylon can be compared with the others. It has a fairly flexible molecule and a strong tendency to crystallise. As a result it is strong and tough, and has a fairly high softening range and melting point.

There are a number of other thermoplastic polymers of some commercial importance, including a series of partially synthetic ones based on cellulose, but those to which reference has already been made account for about 90 per cent of the total production of thermoplastics in Britain. Rather than consider additional thermoplastics, however, let us pass on to the smaller number of important thermosetting materials, in order to see in what ways they differ from the thermoplastics in structure and behaviour.

Although it was not the first of the thermosetting plastics to be produced, it is convenient to start with urea formaldehyde. Urea and formaldehyde react to give methylol urea or dimethyl urea :—

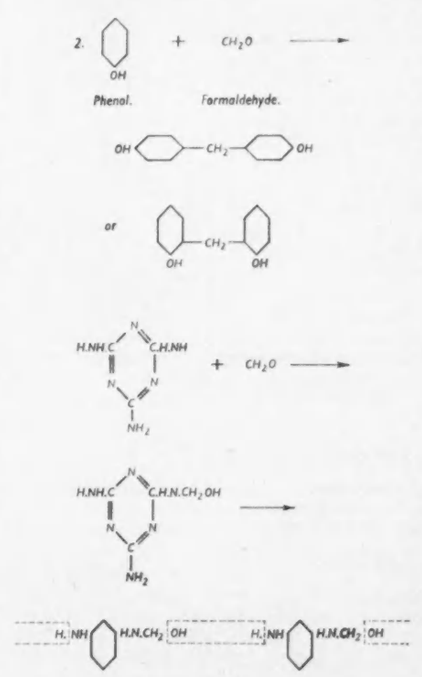


and then, by elimination of water, a so-called condensation reaction, the methylol urea molecules join up to form a resinous solid :—



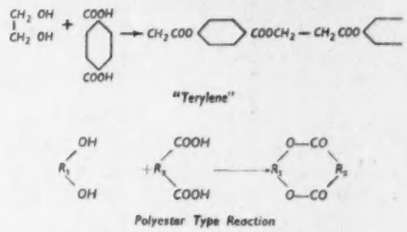
If heated further, these chains of the resin cross-link with one another in a rather random way to give what is, in effect, one enormous macro-molecule.

Until recently, the other two thermosetting plastics of importance were phenol formaldehyde, the earliest of them, discovered by Baekeland, and melamine formaldehyde, formed by the condensation and cross-linking of molecules of the forms :



As might be expected from the highly cross-linked structure of theee three materials, they are relatively hard, stiff and brittle. Urea formaldehyde plastics are the least hard and are clear enough in colour for them to be used for light shades. Phenol formaldehyde, due to the ring structure in the molecule, is harder and stiffer, but is amber in colour and cannot be used for a full range of decorative colours. Melamine formaldehyde is the hardest and strongest of the three ; it has a lower water absorption than the others. It also can be used for pastel shades.

The relatively new polyester plastics are also formed by condensation, or by condensation and cross-linking, of a polyhydric alcohol with a polycarboxylic acid. These resins may be either thermoplastic or thermosetting, depending upon the type of ester formed and the degree of cross-linking :—



The epoxy resins closely resemble the polyester resins in their general characteristics, and in their main applications, although the chemical reactions by which they link and cross-link are different.

There is one other general difference between the thermoplastic and thermosetting resins. The thermoplastic materials are commonly used as plain polymers, without any additions, other than pigments to give colour when desired, or, alternatively, are rendered more plastic by the addition of " so-called " plasticisers, these being substances which may be regarded as dissolving in, or partly dissolving, the polymer. Thermosetting resins, on the other hand, are almost always used with the addition of fillers such as wood flour, macerated fibre, asbestos or mica, to improve their mechanical properties, reduce their cost, or to aid coloration. Alternatively, they are used as bonding agents to form laminates with paper or fabric. In the case of the formaldehydes, the resins are formulated so that they are either thermoplastic powders or viscous liquids which condense further, and cross-link, when they are cured by heating them under pressure. Many of the polyesters and epoxides, however, are formulated as liquid resins which will cure at low temperature, when they become strong and relatively tough. They are particularly suitable for forming fibre glass laminates because they harden under light pressures and with little or no heating. They are also excellent as adhesives, even for metal to metal joints.

Mine Stable Hole Conveyor

To reduce the amount of manpower involved in hand-casting coal when making stable holes at the ends and in advance of mechanised longwall faces in coal mines, Joy-Sullivan, Ltd., of Cappilow, Greenock, has introduced a conveyor known as the " Miniveyor." This conveyor has a lightweight welded steel frame on which an 18in wide belt is carried on full-length stainless steel strips set to give troughing characteristics. A 2 h.p. motor at one end can be coupled to a standard drill panel and it drives the belt pulley through reduction gearing to give a belt speed of 175ft per minute. Up to 50 tons of coal an hour can be handled with the conveyor which can be fitted with a removable hopper above the driving drum to facilitate filling.

These conveyors have an overall standard length of 11ft 4in and can also be supplied in other lengths with drum centres from 8ft to 20ft 4in if required. They can be arranged with 8in castor wheels or skid mountings for movement and positioning purposes, the overall height with wheels being just over 1ft 9in and with skids 1ft 3in. The full overall width at the driving drum end of one of these conveyors is 2ft 8½in.

Batching Plant for Glass Materials

A plant for the automatic batching and mixing of materials used for making glass bottles has been developed by Blaw Knox, Ltd., and installed in the works of the J. Lumb and Co. Division of United Glass, Ltd. This plant is fully automatic in operation and includes programming control whereby the kinds and quantities of materials required for a number of different glass blends are predetermined. It handles some 1600 tons of materials a week, and is capable of delivering forty 1-ton batches of blended materials an hour to storage silos serving the glass furnaces.

A WEIGH batching and mixing plant for glass making materials recently commissioned at the Castleford works of J. Lumb and Co. Division of United Glass, Ltd., is not only designed to promote considerable savings in manpower and space, but also to take full advantage of the speed and precision of modern automatically controlled equipment. This works has a weekly production of some 3,500,000 bottles in a variety of sizes and sorts, from plant served by three furnaces—two of which melt white flint glass and the third amber glass. The batches used for feeding the white glass furnaces consist of two grades of white sand, soda ash, limestone, cullet and various mixer ingredients which are premixed and fed into the main mixing plant as "additives." The amber glass differs in composition from the white flint glass and requires its own special grades of sand, limestone and cullet.

The new batching and mixing plant, which has been designed and built by Blaw Knox, Ltd., handles some 1600 tons of materials a week, and delivers up to forty 1-ton batches of blended materials an hour to within a tolerance of under 1 per cent on any one material in a single batch. It is designed to prepare in one shift and under the control of a single operator, sufficient material to keep the furnaces fully supplied for twenty-four hours. The economies made possible with the plant can be appreciated when it is pointed out that its work was originally effected with three blending stations at each of which three men were employed in two shifts. Now only one man is required for one working shift. Furthermore, storage space was required for each of the materials used whilst now they are delivered directly from road or rail vehicles to a single 920-ton capacity overhead hopper, thus making available an appreciable works area for other purposes.

The general arrangement of the Blaw Knox plant can be seen in the drawing and photographs we reproduce. Materials are delivered by rail trucks to an elevator, at the side of the main batching and mixing installation, where they are dropped into a 15 cubic yard hopper set in a pit below ground level. A table feeder at the bottom of this hopper delivers the material into the buckets of the elevator which is capable of delivering up to 100 tons an hour into the chute of a turnhead at the top of the main storage bin. This bin can be seen in Fig. 1 and the swivel turnhead of its elevator (on

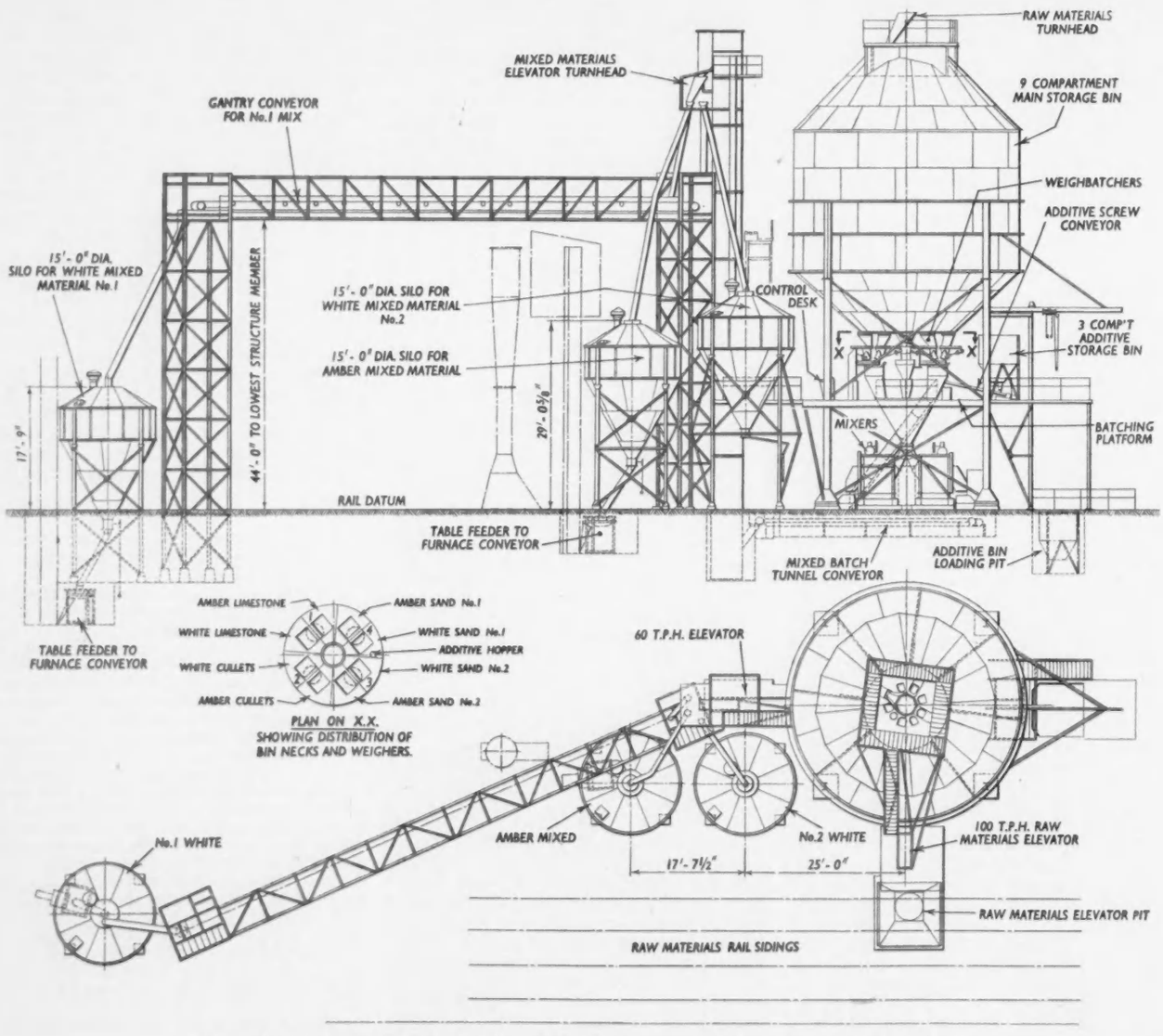


Fig. 1—General layout of plant for batching, mixing and storing materials used for glass bottle making

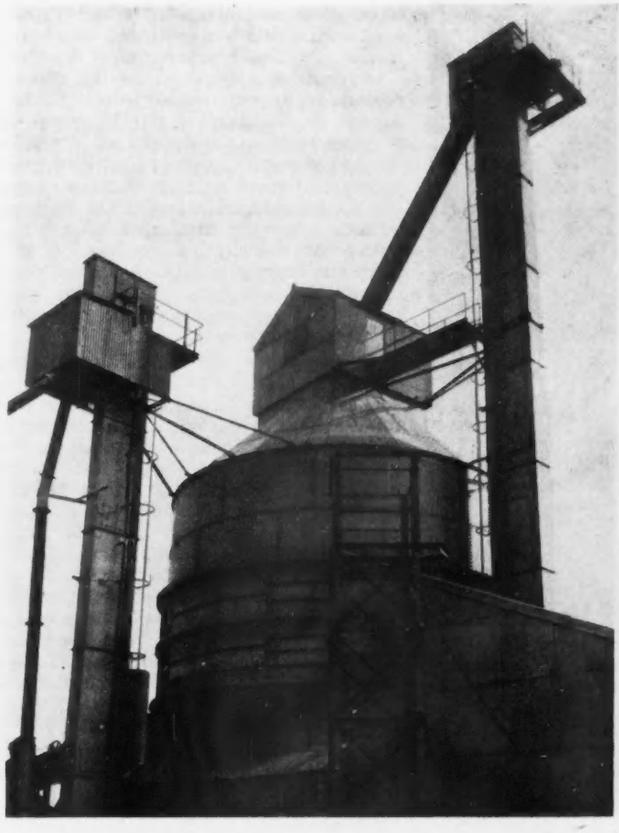


Fig. 2—Main storage silo for materials and loading elevators

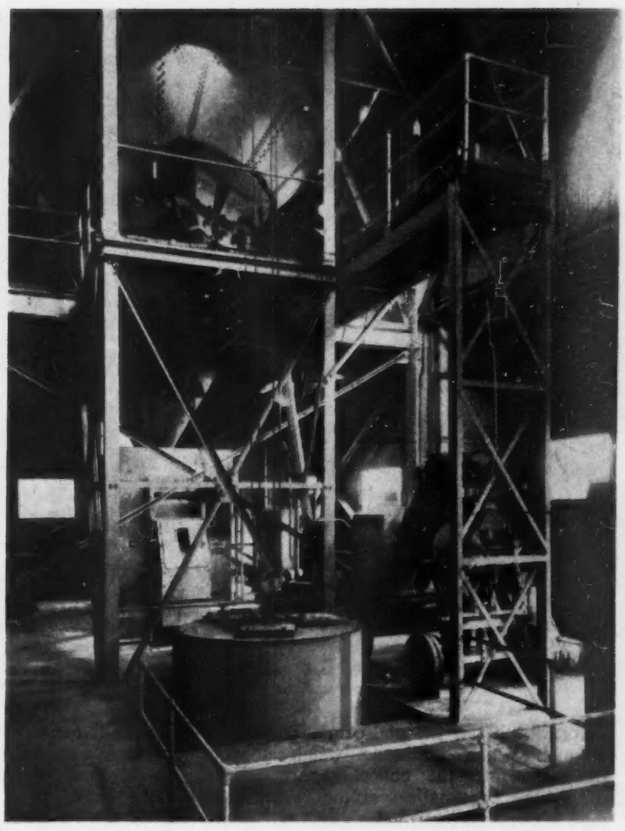


Fig. 3—Batching and mixing plant house

the right) is positioned, by an arrangement of wire ropes from a capstan head at the foot of the elevator, for its chute to be registered over any one of a group of fixed chutes leading to the storage bin sections. Each bin section is indicated by a number on a panel adjacent to the capstan, and the number of the section over which the turnhead chute is set is automatically illuminated. Each of the fixed chutes leading to the bins for sand are fitted with vibrators which are started automatically to prevent the material clogging when the turnhead chute registers over them.

The main storage bin of reinforced welded and bolted plate construction is about 35ft diameter and its interior is divided by bulkheads into eight outer compartments with a central circular compartment 12ft inside diameter. These outer compartments are used for the storage of the eight different grades of sand, limestone and glass cullets and each accommodates about 100 tons of materials ; the central compartment holds about 120 tons of soda ash. A panel at ground level carries a series of bin section indicator lamps which are illuminated when the contents of a section reaches a predetermined height. When its lamp is illuminated there remains sufficient room in a section to take one further load and empty the pit hopper to leave it ready for handling the next grade of material.

The storage bin is supported on a riveted and bolted steel section structure on which there is mounted, some 17ft above ground level, the main control platform and batch weighing equipment shown in Fig. 3. In the base of the storage bin there is a discharge neck for each compartment and a discharge control gate or valve is mounted at the lower end of each neck. Radial gates fitted on the compartments used for sand and glass cullet storage have a full opening of 12in by 18in and are operated by pneumatic cylinders under control of solenoid-operated air valves. To prevent jamming of the cullet discharge valves by large pieces of glass when they are closing, cast iron choker weights are fitted. Semi-rotary valves, specially designed to handle more finely powdered materials, which are fitted on the limestone and soda ash compartments are also operated under solenoid control by pneumatic cylinders.

On the platform below the bin compartments there are grouped five weigh hoppers (shown in Fig. 4) into which the materials are delivered ready for batching. At the commencement of a weighing operation the gate of a compartment is fully opened giving a full flow of material into the weigh hopper. At a predetermined underweight the gate is automatically and rapidly opened and closed to impart a dribble feed effect and, when the correct weight of material has been delivered into the weigh hopper, the gate is automatically closed. This weighing operation is carried out simultaneously and automatically from each of the selected compartments containing the materials required for specified glasses. The gates on the soda ash and limestone compartments are operated by a dual-pneumatic cylinder arrangement in which a common piston rod operating the gate lever is actuated by 2½in and 5in cylinders. The 5in cylinder opens the gate, and at its full opening stroke the 2½in cylinder piston is reciprocated rapidly to prevent bridging or sticking of damp material. On the closing movement at the underweight mentioned above the large cylinder closes the gates and the dribble feed is imparted by a reciprocating movement of the smaller cylinder.

The bin arrangement is such that the materials for making either white or amber glass can be weighed, the feed gates being interlocked so that only the selected grades are weighed, the other gates being rendered inoperative. Each pair of compartment gates feeds into a common weigh hopper through a breeches chute or collecting hopper. The weigh hoppers of welded steel plate construction are each complete with a weighing lever system coupled through flexible transmission wires to a weighing dial cabinet. The glass cullet hopper has a maximum weighing capacity of 1000 lb ; hoppers for the sands have 1500 lb capacity, and those for limestone and soda ash 500 lb.

A separate installation at the side of the main batching equipment, which is to be seen in the foreground in Fig. 3, is used to supply the additives for each batch. For this installation materials are pre-mixed and delivered into a three-compartment bin which is lowered into a pit at the side of the plant. This bin is raised by an electric hoist block to the batching platform where it is traversed along to position its outlets over the inlets of a group of three separate screw conveyors. Each of these screw conveyors is used to deliver one class of additive only in accordance with the type of glass being blended. The appropriate screw conveyor is started automatically at the commencement of a weighing cycle and it delivers material into a small weigh hopper which has a maximum weighing capacity of 50 lb—the usual quantity of additive required for a batch being between 10 lb and 30 lb.

The weigh hoppers used for sand and cullets have pneumatically operated radial gates in their bases, and those for limestone and soda ash cone seating valves. The additive hopper has a counterbalanced discharge door the latch of which is released by a solenoid operated mechanism simultaneously with the other hopper gates. Through these gates the hoppers are discharged into a cone-shaped collecting hopper

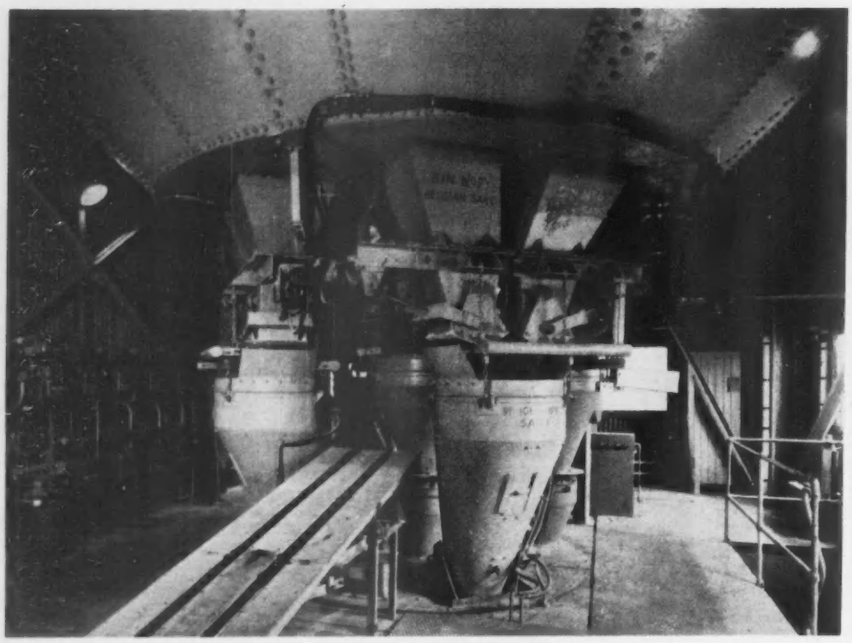


Fig. 4—Batching platform with feed gates above weigh hoppers for the various selected materials. The screw conveyors for the additives can be seen in the foreground

suspended below the platform. The chutes through which the sand weigh hoppers discharge into the collecting hopper are fitted with pneumatic vibrators which start automatically to prevent bridging as discharge starts. The collecting hopper base is fitted with a two-way chute, so that its contents can be discharged through sealed trunking into either of two 1 cubic yard capacity drum mixers to be seen in Fig. 5. These mixers are arranged for power discharge through a chute which is inserted into or withdrawn from the mixer drum by a solenoid-operated pneumatic ram.

The main control desk of the installation, illustrated in Fig. 6, is situated on the weigh batching platform and it includes a sloping desk control panel with a weighing dial cabinet at the rear, as shown in one of our illustrations. This desk carries all the controls necessary for the automatic batch weighing and discharging, the selection of mixer to be charged, and the discharge of the mixers.

Once the weighing and batching cycle selected by a rotary switch has been started the plant continues to operate automatically until it is stopped for re-setting to a different mixture, a counter being provided for recording the number of batches mixed during automatic operation. Each weighed batch is automatically discharged into a mixer and when all the hopper gates are closed, the weighing cycle for the next batch re-commences. Alternate batches are delivered to the mixers in turn by the automatic change-over of the collecting hopper delivery chute gate. Green indicator lamps are provided in the control panel for each weigher to show when all materials are correctly weighed. Red lamps are illuminated should there be an overweight above a preset amount and discharge is interlocked until weight is corrected.

The plant is electro-pneumatically controlled throughout and the flexible air supply lines to the pneumatic rams that actuate the various units are controlled through banked solenoid-operated valves situated each side of the cabinet of the main control desk. In emergencies, the automatic cycling equipment of the plant can be switched over to hand control of the individual units through two sets of palm buttons which operate the air valves. A water-cooled air compressor with a 100 cubic feet per minute free air delivery at 100 lb per square inch pressure feeds the air lines, each of which is fitted with an oil-mist lubricator and water separator.

Interlocks are provided in the control equipment to ensure that: (1) Batches cannot be discharged from the group of weighers until all materials are correctly weighed to preset quantities; (2) Feed gates cannot be opened until the discharge gates of the weighers are closed; (3) Weighed batches cannot be discharged to a mixer unless the discharge chute is withdrawn from the drum; and (4) A mixed batch cannot be discharged until it has been mixed for a predetermined time, controlled by a batch timer on the panel.

The weighing unit has five springless pendulum dials and the dial mechanism is coupled to contacts which control the cut-off of feed gates and valves. One contact is preset to operate underweight to set the bin gates to fine dribble feed; the second contact operates at correct weight to close the feeder gate or valve, and a third contact operates if overweight is registered. Provision is made for making changes easily and quickly through a rotating selector lever at the end of the dial cabinet to any one of six preset proportions of mix; for example: three for white glass mix, two for amber glass mix and one for a cleaning batch mix. Operation of the selection switch also sets interlocks between the white and amber material feeder gates and at each position of this switch indicator lamps on the dial panel light to show which preset mix is being weighed.

The mixers discharge down a collection chute on to a 16in wide troughed belt conveyor situated in a trench below the mixing house floor level. The material is carried on the belt past a magnetic separator, which removes any tramp iron, and delivered into the boot of a 62ft high bucket elevator. This conveyor-elevator system is designed to handle some 60 tons per hour of the mixed materials, and at the head of the elevator there is a swivel chute turnhead. The turnhead can be set for its chute to deliver materials into one of four chutes leading respectively to a white grade glass storage silo, an amber grade glass silo, a horizontal conveyor mounted on a gantry and leading to a second white glass silo and a ground-level discharge station. The motor starters are sequence-interlocked to prevent discharge unless all units are running, and the turnhead delivery position is correctly located.

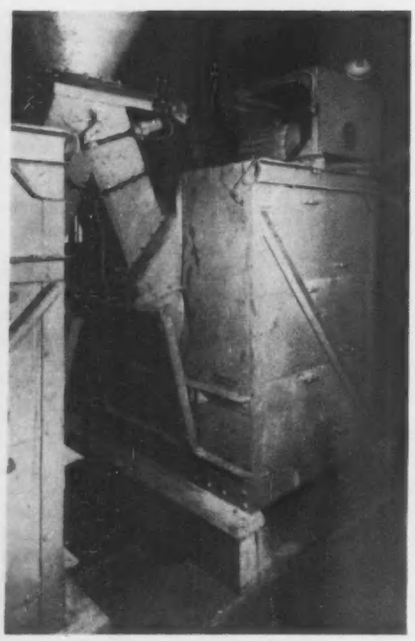


Fig. 5—Two 1-cubic yard drum mixers fed alternately through two-way chute from batch collecting hopper above

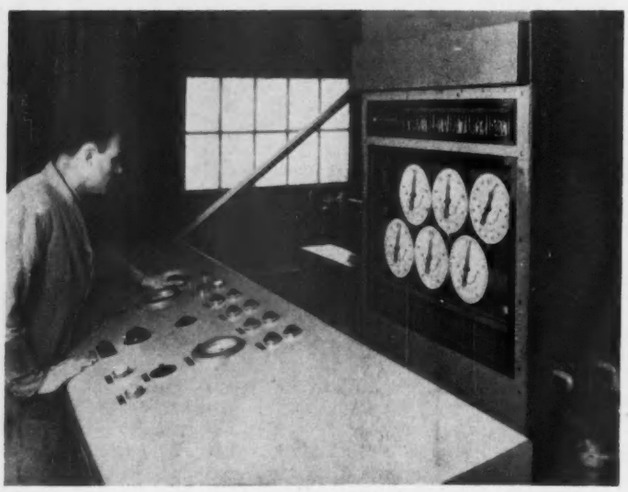


Fig. 6—Control desk and weighing cabinet for automatic repetition batch control

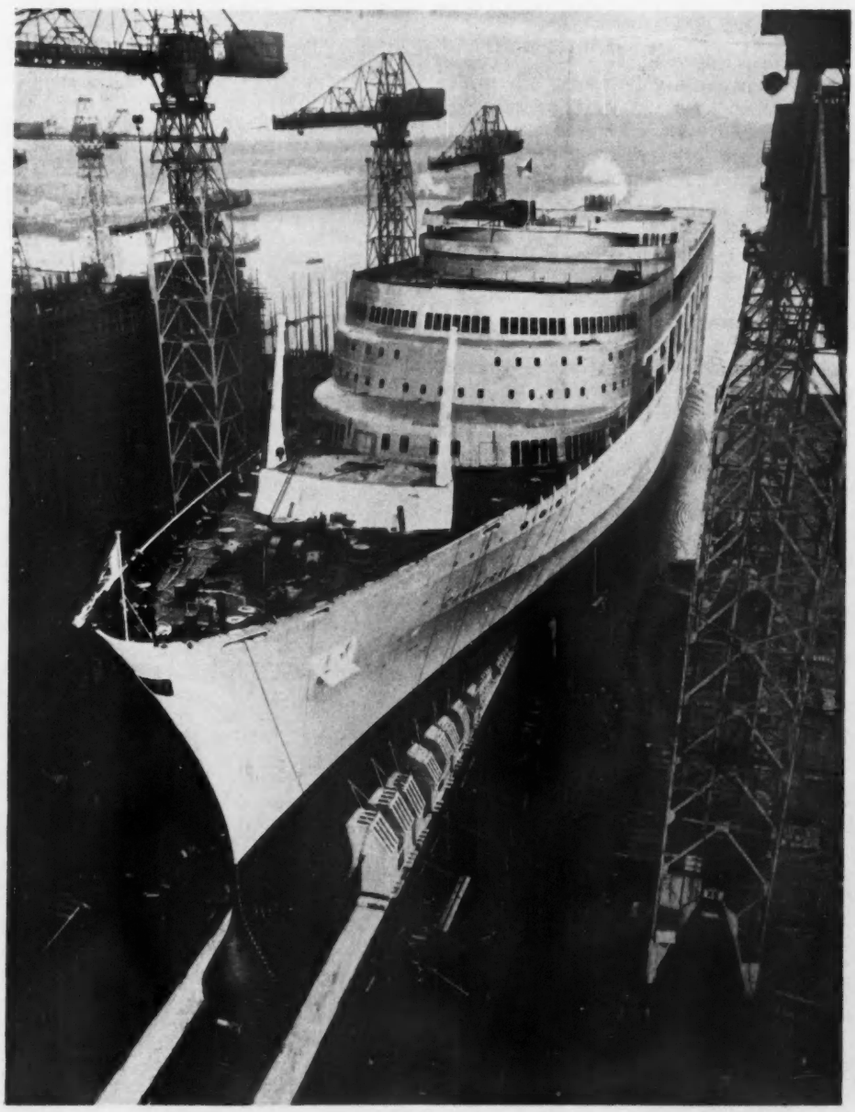
It should be mentioned here that when changing over from amber to a white glass mix a "cleaning" batch is taken through the whole system from the weigh hoppers to the elevator turnhead. This cleaning batch is discharged from the turnhead down a chute to trucks at the ground discharge station for use in later amber mixes. By this method of cleaning the whole batching system any chance of contamination of initial batches when changing over from one mix to another is avoided.

The turnhead delivers amber and white glass mixtures directly into either of two 15ft diameter 60 tons capacity storage silos. Three grades of white glass are produced in the plant No. 1, No. 2 and No. 2A and either No. 2 or No. 2A mix can be stored in the silo fed directly from the turnhead. No. 1 mix is delivered by the turnhead chute on to a troughed, 16in wide, belt conveyor carried some 44ft above ground level on a gantry. At the end of this gantry the material is deposited into a chute feeding into a third 60-ton storage silo. The silos used for storing the No. 1 white mix and the amber mix have manually-operated radial discharge gates and are connected through chutes to underground table feeders. These feeders control the discharge from the silos to the elevators on the glass furnaces at rates up to about 10–12 tons an hour. The silo holding No. 2 white mix is set at a higher level than the two others and is designed for direct discharge into vehicles.

The installation of this batching and mixing plant has involved many problems as it had to be erected on a very congested site, and full production with existing plant had to be maintained throughout its construction. The main batching and mixing plant has now been in service for some time, and all that now remains to be done is the erection of the conveyor bridge and storage silo for the No. 1 glass mix.

Launch of P. & O. Liner "Canberra"

ON Wednesday, March 16 Dame Pattie Menzies, the wife of the Prime Minister of Australia, gave the name "Canberra" to the P. & O. liner before launching the ship from her berth in the yard of her builders, Harland and Wolff, Ltd., Belfast. The name symbolises the role which the owners have fulfilled in the development of Australia's overseas trade during the last century. Our illustration shows the liner moving down the ways and gives a view of extensive aluminium alloy superstructure. Also clearly seen is the bulbous forefoot and the forward launching cradle. The ship is expected to enter service in 1961, and in this service "Canberra" will sail from London to Australia for the P. & O. Company and then continue on to the west coast of North America in the service of the Orient and Pacific Lines. A total of 585 first-class and 1650 tourist-class passengers will be carried, and as designed the liner has a length between perpendiculars of 740ft by 102ft beam by a depth to "E" deck of 41ft 6in, and a speed of 27·5 knots. Voyage requirements related to distances between ports of call largely determined the speed, which in turn, due to the speed/length ratio selected, influenced the main dimensions and hull coefficients.



P. & O. liner "Canberra" moving down the ways

Of mixed riveted and welded construction, the liner has a gross tonnage of 45,000 and incorporates about 13,000 tons of steel in the main hull, while the structure above the promenade deck is almost entirely of aluminium alloy, of which about 960 tons has been supplied by the British Aluminium Company, Ltd. There are four tiers of passenger accommodation in the superstructure which, when complete, will have built into it about 1000 tons of light alloy. The use of aluminium alloy on this scale is estimated to have saved nearly 1500 tons of structural weight and to have enabled many more passengers to be carried. The material has been welded, the panels of deck plating and deckhouse sides being prefabricated in the shops by the inert-gas metal arc process.

Passenger comfort has been the keynote of the internal design; cabins have been carefully planned and materials selected, while overall consideration has been given to the suppression of noise. The ship will be fully air conditioned, using the "Thermotank" system, and wind tunnel tests have established air flow and velocity distribution over the ship so that funnel design should eliminate the soot nuisance and the descent of funnel gases on to the decks, while superstructure design and location of screens should provide adequate shelter on the open decks. For handling baggage automatic loading has been devised, the system including cross deck conveyors to feed a Collis preselective "Vertiveyor" which will discharge baggage at any preselected deck. Other conveyors will deliver to the baggage room. For cargo handling The Carron Company are supplying a side-loading device which was described in our issue of January 15.

Design studies undertaken by the Yarrow Admiralty Research Department formed the basis for the selection of turbo-electric propulsion machinery driving twin screws and developing a maximum of 85,000 s.h.p. Steam at 750 lb per square inch and 960 deg. Fah. will be raised by three main boilers of Foster-Wheeler "E.S.D." design, burning oil fuel under Howdens forced draught system, and one auxiliary boiler of similar design. The British Thomson-Houston Company, Ltd., the management company of Associated Electrical Industries, Ltd., Heavy Plant Division, is manufacturing the turbo-electric propelling and auxiliary machinery consisting of two 32,200kVA alternators each driven at 3087 r.p.m. by a uni-directional single-cylinder, seventeen-stage, turbine. Propulsion is by two double-unit, forty-two-pole motors developing 42,500 maximum shaft horsepower at 147 r.p.m. and 34,000 service shaft horsepower at 136·5 r.p.m. Additional details of the main machinery were given in our issue of March 4, page 397. G. and J. Weir, Ltd., is supplying the sea water distillation plant and other auxilaries, the English Electric Company, Ltd. is manufacturing the a.c. distribution switchboard and lighting transformers, while electrical power is provided for ship and hotel services by four 1500kW, 60 c/s turbo-alternators.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible or the opinions o, our correspondents)

ANTI-VIBRATION FOUNDATIONS FOR DROP HAMMERS

SIR,—I am grateful to Mr. Allaway of Absorbit, Ltd., for his letter discussing my article on anti-vibration foundations for drop hammers.

First, may I point out that nowhere in my article did I say or infer that light viscous damping would produce a greater dynamic load on the ground than that due to the springs. I made it absolutely clear that my remarks applied only to the case of heavy damping. Indeed I said " Where the very highest insulation of the foundation is required dampers may have to be used." The main point of my remarks was to show that the diagram published by Absorbit, Ltd., was wrong in that damping of the magnitude indicated by the firm's figure, which I copied, would lead to a bigger dynamic force being applied to the ground than that due to the compression of the springs. If Mr. Allaway will substitute appropriate values for the damping constant in the formula which he gives in his letter he will find this to be true. Also, I must stress again that the force on the ground due to the dampers is built up much more rapidly than that due to the compression of the springs. The more rapidly the force is applied the greater the ratio of kinetic energy to strain energy in the ground. This is clearly undesirable.

Regarding natural frequencies of foundations on ground, I stated quite clearly in my article that every foundation has a natural frequency of oscillation on the ground. I quoted not only my own results, but those of other workers as evidence. The important thing is that this is not a unique frequency for any particular type of ground but varies with the size, shape and weight of the foundation.

Regarding the possibility of resonance of the vertical vibration of the hammer with the so-called natural frequency of the ground I would point out again that when any elastic system is suddenly disturbed it always oscillates at its natural or resonant frequency. This is unavoidable. But it is of no significance unless there is a cyclically applied external driving force to build up the energy in the system. This external force can only be the hammer blow and it is resonance with this that has to be avoided. The resonance can be a sub-harmonic one, and for this reason the logarithmic decrement due to damping must be greater if the springs are very soft and, therefore, of low natural frequency. The damping force which is, of course, applied through the damper to the ground must therefore be high. It is for this reason that with many installations, although, of course, not all, the most satisfactory solution is to use stiffer springs than are recommended by Absorbit, Ltd., and allow leakage of energy into the ground to replace dampers.

Regarding types of springs it may be of interest to remark that delivery of rubber springs is not now so quick sometimes as it was when my article was written some months ago. As Absorbit, Ltd., has no doubt discovered, the client is normally in a tremendous hurry if a normal foundation is causing trouble and he needs to replace it with an anti-vibration one.

I would hasten to make it clear that my remarks about breakage of dampers was not in any way meant to imply that any of the dampers made by Absorbit, Ltd., had broken.

W. EASTWOOD

University of Sheffield,
Department of Civil Engineering,
March 15, 1960.

AFTERMATH OF GUILLEBAUD

SIR,—Your forthright leader " Aftermath of Guillebaud " prompts me to trespass on your space once more. Being a countryman, living in an area of uneconomic branch lines, one is conscious of the huge burden these must be on the Commission. Now, more than ever, the railways should contract to their (possibly ?) profit earning core and be allowed to close branch lines much more drastically, without having to go through the long process now necessary.

For one who is convinced that in agricultural areas, anyway, railways have become an anachronism, it is particularly irritating to find that in many cases, passenger traffic is closed down but the line is kept open for goods traffic. The local population loses a service without any compensating advantages, and violent opposition is always met with. On the other hand, if the line were closed completely and turned into a road, congested market towns could have car parks on the old station areas, and the route would in many cases act as a by-pass. Thus the population would gain rather than lose mobility. The goods traffic involved is small, often mainly coal for local merchants which could perfectly well come by road.

When county authorities are approached with these ideas they consider it a complete answer to state that as the Commission do not propose to close the line, they are powerless. To give but one example. The road from Newton Abbot to Morton Hampstead is narrow and winding and is grossly overloaded in the tourist season. A branch line closed except for a minute amount of goods traffic runs parallel with this road. It cannot be considered for road development although the line must be showing a heavy loss to the Commission.

D. F. C. VOSPER

Llandovery,
Carmarthenshire,
March 21, 1960.

THE FAIRLIE LOCOMOTIVE

SIR,—In the issue of THE ENGINEER for March 11 I was surprised to find that a final paragraph of acknowledgments had been omitted from my article on the Fairlie locomotive, and I should therefore be grateful if you would rectify the apparent discourtesy by publishing it here.

The paragraph should read as follows :

" In conclusion the author wishes to thank all those engineers and railway historians, both in this country and overseas, who have assisted in making this review as complete as possible, particularly J. F. Bruton of Fulham ; C. H. Dickinson of Ilford ; Eric Sundstrom of Bromma, Sweden ; Antonio da Anda, C.M.E. Uruguay State Railways, Montevideo ; C. P. Fisher of Boston, U.S.A.; L. Douglas, General Manager, South African Railways and Harbours. In addition much valuable help has been freely given by the technical staffs of the Hunslet Engine Company, the Yorkshire Engine Company, the Vulcan Foundry, Ltd., and the North British Locomotive Company, Ltd. For the use of photographs and drawings, acknowledgment is due to the following : Figs. 1, 2, 3, 7, 8, 10, 12, 13, 14, 23, 25 and 35, courtesy of Editors of *Engineering* ; 31, Eric Sundstrom of Bromma, Sweden ; 4, 32, 33, 34, North British Locomotive Company, Ltd.; 5 and 6, Locomotive Publishing Company, Hampton Court ; 9, Signor Antonio da Anda, Montevideo ; 11, West Australian Government Railways ; 15 to 22, Vulcan Foundry, Ltd.; 24 is based on a drawing in *The Locomotive* for 1929, page 384 ; 26, South African Railways and Harbours ; 27, 28 and 29, Yorkshire Engine Company ; 30, Anglo-Chilian Nitrate and Railway Company ; 36, American Locomotive Company.

R. A. S. ABBOTT

Oxford,
March 15, 1960.

Book Reviews

Laplace Transforms for Electronic Engineers. By JAMES G. HOLBROOK. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 50s.

WHEN logarithms are used to simplify the processes of multiplication and division, tables of logarithms and anti-logarithms are referred to as a drill and the user is not concerned at the time with the mathematical theory behind their compilation. Tables of Laplace transforms can be used in a similar manner to simplify many of the processes of differentiation, integration and the solution of differential equations, and in particular to solve the problems that arise in electrical networks. With the aid of a table of Laplace transform pairs and the elementary knowledge that is required to set up the subsidiary equations and interpret the results, it is possible to make considerable use of this operational method : no understanding of the underlying theory is required.

The normal approach in a text book for engineers on Laplace transforms is to present an elementary introduction and then to proceed to develop their applications to the solution of practical problems. The mathematical basis of the methods is either dealt with later in the book, relegated to appendices, or even omitted.

The author of this book has adopted an entirely different approach. For example, integration around a pole and the use of residues are given in the beginning of the book. It is his intention to make the reader become familiar from the outset with working in the transformed complex plane, understand the methods involved, and not treat transformation and its inverse as automatic operations. The foundation is laid in the first chapter. After a revision of the elements of complex numbers, transformation between complex planes is explained as a " mapping " process. Examples of transformations are given, and their use in simplifying practical problems is illustrated. The concepts of poles and contour integration are very clearly explained. By considering the function in the complex plane as the surface of an irregular earth and a pole as an infinitely high peak, a visual picture is given that considerably helps the understanding.

The second chapter starts with a consideration of the Fourier series and integral and the Fourier transform, from which the Laplace transform is developed by a generalisation process in a clear and logical manner. Transforms of the more common functions are then derived and tabulated. In this book s is used as the complex variable. Although it is probably more usual to use p, there is no confusion. Small letters are used for functions of time and capitals for functions of s. A distinction is made between periodic functions which are denoted by $p(t)$ and $P(s)$ respectively and non-periodic where $f(t)$ and $F(s)$ are used.

It is in the treatment of the inverse Laplace transform that this book differs from most others. Instead of splitting up the function of s into a number of partial fractions whose inverse can be determined by inspection, the method advocated is to work from first principles with the inverse Laplace integral, " removing a pole " and using residues as explained at the beginning of the book. This method demands a good working knowledge of the theory and a comprehensive chapter is devoted to eight main theorems of Laplace transforms. Included are the " shifting " theorem, the convolution theorem, and the scale change theorem. They are all illustrated by their application to electric circuit problems. The application aspect is reinforced in the following chapter on network analysis. Not only does this include the usual network combinations of resistance, inductance and capacitance, but a number of practical electronic circuits are analysed such as the Wien-bridge oscillator, active as well as passive integrating and differentiating networks, and R-C low-pass filters. When dealing with iterative networks a short cut method is given, but in this case not fully explained, for finding the transfer function from Pascal's triangle. Singled out for special mention is the subject of mutual inductance which, it is suggested, normally receives scant attention. It is arguable whether the treatment and the rules which are given for finding the " sign " associated with M in inductively-coupled circuits clarifies or confuses, particularly if the reader has his own established method. A further possibility for confusion is the sign convention for currents that is adopted throughout. The author adheres strongly to the opinion that current should be considered as electron flow and he refers scathingly to those who continue to adopt the convention of current as a flow of positive charges.

An important part of the book for the modern electronic engineer is the chapter on the transform of special waveshapes and pulses, as the technique of testing circuits with other than sinusoidal inputs is now well established. Both individual pulse shapes and pulse trains are considered, and finally pulsed periodic functions. In the final chapter a number of special applications of the Laplace transform are given. Again of importance to the electronic engineer is their application to the design of Butterworth filters. A procedure is given, but without proof, for locating the poles of a Butterworth function in the s plane and practical rules are included for the synthesis of the filters, that is, finding the circuit from the transfer function. The last application is the use of the Laplace integral to find the sum of an infinite series. The appendices at the end of the book deserve special mention. They include tables of no less than seventy-two transfer functions and 234 Laplace transform pairs.

There is no doubt that the author has succeeded in his original approach to this important subject. He has cleverly contrived to present the reader with all the necessary mathematics that will enable him to understand fully the processes involved and at the same time not to burden him with rigorous proofs and qualifications. A most readable book has been produced that is well suited for self-study. It is written in a light and encouraging style. The mathematics is liberally illustrated by worked examples, all taken from the field of electrical engineering. A few problems are set at the end of each section and for the student who wants more there are always the appendices. A few minor and obvious errors have been noticed. Equation 2.41 is incorrect but the table which follows is correct. On page 150 it is stated that charge in the time-world goes over into voltage in the s-world ; current was intended instead of voltage. These errors and the few criticisms that can be made in no way detract from the overall merits of the book. It has been written for the electronic engineer to develop his knowledge of circuitry and networks by the application of Laplace transform theory and it is admirable for this purpose. Some material and methods are included that will be new to most engineers, and the extensive appendices make it a valuable reference book.

The Corrosion and Oxidation of Metals : Scientific Principles and Practical Applications. By ULICK R. EVANS. Edward Arnold (Publishers), Ltd., London. Price 140s.

THIS is a very big book. Big in scope, because it covers the whole field of the corrosion and oxidation of all metals and alloys. Big in size, because it contains 1094 pages of wisely-chosen matte paper, 6¼in by 9¼in, excellently printed and illustrated with over 200 line diagrams. Big, above all, in value, because the corrosion and oxidation of metals now limit the work of every single engineer throughout the whole world. Recognition of the great significance of corrosion has during the last two decades resulted in the formation of many teams of corrosionists, all of whom will welcome this volume as a classic masterpiece. Every Service and every large industry now employs advisers and researchers in corrosion problems and many of the leaders among these corrosionists received their early training in the Cambridge laboratories and lecture rooms under the author of this book. Ulick R. Evans has been recognised and honoured internationally as expert in the scientific principles underlying the phenomena of corrosion and oxidation. For some forty years he has himself carried out corrosion researches in Cambridge University, where he published his first small book on *The Corrosion of Metals* as long ago as 1924, and where much later he was appointed the first Reader in the science of metallic corrosion.

In 1937 he published his long book, *Metallic Corrosion, Passivity and Protection*, which was immediately accepted as authoritative. By now the growth of the new science had accelerated so that when the second edition of that book appeared nine years later, the author had so worked on its revision that it almost amounted to a new book. Clearly, this was too large a book for most students, who need to know something about corrosion but do not intend to specialise in that subject. The author therefore met their need by writing a relatively small book of 211 pages, *An Introduction to Metallic Corrosion*, and this has been the standard textbook for students since it appeared in 1948. Thus, with the experience of writing those four books behind him, the author was moved to write a completely new book, based on a new plan, and after five years of very hard work on his part, we now have to thank him for a classic volume which will be highly esteemed in every scientific library.

His author index contains about 3000 names in its twenty-eight pages ; a great tribute to his extraordinary diligence and assiduity. It is followed by no less than fifteen pages of carefully checked subject index which is surprisingly up to date, despite the fact that the subject has grown so wide that at the March 11–18, 1960, Conference in Texas of the National Association of Corrosion Engineers, there were presented no less than ninety-three technical papers. The main body of the book consists of twenty-two chapters, all written by the author himself, but each vetted by one or more scrutineers, all of whom are acknowledged by name ; as indeed are many others who have provided information and advice or given permission to use matter or diagrams.

This volume gives Dr. Evans's personal views on corrosion, and each chapter is headed by his synopsis. These synopses are so excellent that they should be read one after another ; for thus they offer a fascinating opportunity of surveying the whole field of metallic corrosion through the eyes of a pioneer and lifelong prospector. As the chapters unfold, one sees the experimental work that influenced the author in reaching the views which he states ; his paragraphs or sections being provided with references to papers or books. In the eighteen chapters of the qualitative section of the book, engineers will find up-to-date evaluations of many of their corrosion problems ; such as concern, for example, inhibitors, bimetallic contacts and crevice corrosion, buried and immersed metalwork, boilers and condensers, atmospheric corrosion, protection, corrosion fatigue and other types of conjoint action. The last four chapters form the quantitative section of the book, dealing with the velocities of measurement and testing, of film growth, and of wet corrosion : concluding with statistical considerations.

Engineers whose little knowledge of chemistry and physics handicaps their study

LETTERS AND LITERATURE *(Continued)*

of corrosion problems, should be grateful to the author for his two really notable appendices. The first summarises, in fifty-five pages, modern ideas about general and inorganic chemistry. The second similarly summarises, in thirty-four pages, physical chemistry and electro-chemistry. An executive who realises that he must pay attention to corrosion prevention, but almost fails to understand the technical language used by his "boffins," would be well advised to spend a week-ened reading these two appendices, and the short addendum on inhibition and passivity.

The printing of the book matches the excellence of its contents and the reader is helped by the practice of putting the chapter heading at the top of each left-hand page, and the chapter sub-headings at the top of each right-hand page. For many years to come this volume will be read by scientists, engineers and designers, and used in all technical libraries as a trustworthy reference book.

Kinetics of High-Temperature Processes. Edited by W. D. KINGERY. John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 108s.

THE era of the classic volumes, which were the works of the master's own hand, is almost past. Science to-day is followed by a host of devotees whose searches fan out in many diverse directions. Hence it comes that there is a fashion for books which are by no means the work of one man but are collections of papers written by different authors, whose studies have led them to follow divergent paths from the windings of which the editor hopes that they have caught a glimpse of some notable aspects of the truth which the editor thus is better able to visualise as a whole. This prevailing fashion is followed in this book, which originated in a conference on the kinematics of high-temperature processes, held at M.I.T's Endicott House in June, 1958, and it is published jointly by The Technology Press of Massachusetts Institute of Technology and John Wiley and Sons, Inc., New York.

The conference was composed of scientists coming from about forty participating organisations and they were photographed together for the frontispiece. Very considerable planning must have preceded the conference because the U.S.A. men came from a dozen different universities, seven U.S.A. government laboratories, and ten of the largest industrial laboratories. There were also present three scientists from England, two from Germany, one from France, and one from Holland.

All of these authors were active in the field of high-temperature kinetics but approached it from their several quite different points of view. Fashion has it that one refers to these as several different disciplines, systematic trainings intended to develop the mind along certain lines; mainly in this case chemistry, ceramics, metallurgy and physics. It seems odd, therefore, to see no contribution from the University of Michigan, where a professor teaches engineering materials, advanced ceramics and process metallurgy. This inter-disciplinary approach may prove stimulating to the participants but in book form it requires a much clearer and more elementary fundamental introduction.

If this were merely a report of a symposium, written only for the participants, the absence of such an introduction for laymen might be excusable. But this is published as a book for sale to all the libraries of the world in the hope that people other than the existing specialists will read it. As such it requires a more explanatory preface or introduction and it should include a glossary of terms. Neither in the preface nor in the introduction can one find clearly stated why these forty people were called together at obviously great expense, and what were their terms of reference. Since the United States Air Force provided partial support for this conference one may infer that they had in mind problems of materials for rockets and satellites. In any case scientists from other parts of the western world were brought in to help discuss fundamental aspects of high-temperature kinetics in non-metal systems.

It is to be wished that the editor of this volume had given his own definition of his title. Is kinetics still the branch of mechanics which comprises the phenomena of motion as affected by force ? Is it still the modern equivalent of dynamics in the restricted sense ?

The present book is intended to make the conference discussions available to scientists, technologists and engineers concerned with high-temperature processes in general, and with non-metal systems in particular. In it the reports of the contributors are grouped in seven parts, each of which has a short preface, thus : (1) Imperfections and diffusion in non-metals. (2) Diffusion in liquids and liquid-solid reactions. (3) Nucleation and grain growth. (4) Sintering and vitrification. (5) Phase transformations. (6) Solid-solid reactions. (7) Solid-gas reactions. Including author and subject indexes it extends to 326 pages, with many line diagrams, some photomicrographs, and much mathematics. The thirty-five papers are not headed by synopses, but they are each ended by useful references and some of them have helpful summaries or conclusions.

In general, reactions important for the application and study of non-metallic solids at elevated temperatures are heterogeneous processes involving more than one phase.

The volume will be valued by those who are concentrating on high-temperature processes in general and non-metal systems in particular. It will not be easy reading for older engineers but it deals with matters which may well indicate directions in which engineering applications of kinetics will proceed.

Contribution à l'étude des ultrasons aériens: production et applications. By R. BOUCHER. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.79. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr.2548.

FOG can be dispersed and aerosols precipitated by the action of ultrasonic sound. The author describes a novel design of siren, called a "multi-whistle," for frequencies from 7 to 100 kc/s without limitation as regards power output. The conditions of its application to fog on airfields are investigated as well as certain industrial applications (fumes from an electric furnace).

Books of Reference

The Instrument Manual. United Trade Press, Ltd., 9, Gough Square, Fleet Street, London, E.C.4. Price £5 5s.—This third edition follows the general scheme of the second edition of 1953 but certain sections have been expanded or otherwise modified in order to present a balanced picture of the whole field of instrumentation as it appears after some six years of very rapid development. The manual has twenty-six sections. Navigational instruments have been omitted in the present volume (although automatic pilots and flight control systems are included), but a section on analogue computers replaces them. Microscopy and smoke density measurement are now individually treated. Fifteen sections include contributions by specialist authors. The work is copiously illustrated with examples of typical commercial instruments and diagrams explaining basic principles. Measurement by instruments of one kind or another being an essential part of control, the manual includes an automatic process control section, and details are given in the section on counting and timing instruments of devices such as time cycle and sequence controllers. All sections are followed by a buyers' guide of products and their makers, while manufacturers are also listed alphabetically at the end of the volume. The index runs to twelve pages and is followed by a commercial products section, in which brief descriptions of equipment are given under their manufacturers' names in alphabetical order. The manual forms a useful guide to practice in most forms of instrumentation, and may suggest to users new directions in which the art can help them. The technical descriptions are necessarily brief, for this is a reference and not a text-book, but bibliographies in each section provide for those who wish to pursue a subject in detail.

British Petroleum Equipment. 1959/60 edition. The Council of British Manufacturers of Petroleum Equipment, 2, Princes Row, Buckingham Palace Road, London, S.W.1. Price 50s.—This is the seventh edition and more than 300 members are represented in the catalogue pages, while more than 2000 items of equipment appear in the classified list. The volume records the names of the members of the various committees and gives a list of members, together with a brief note upon the principal products of each. There is a classified list of equipment and services occupying fifty-six pages, followed by nearly 800 pages which give particulars and technical data, together with illustrations of the products of individual firms.

Books Received

Simplified Calculus. By F. L. Westwater. English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 10s. 6d.

Work Study. By R. M. Currie. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 22s. 6d.

Textile Engineering Processes. Edited by A. H. Nissan. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 60s.

Vocabulaire Technique. Fifth Edition. Edited by Francis Cusset. Editions Berger-Levrault, 5, Rue Auguste-Comte, Paris (VIe). Price NFr.16.

Handbook of Electrochemical Constants. Compiled by Roger Parsons. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 30s.

Available Energy and the Second Law Analysis. By Edward A. Bruges. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 25s.

Elements of Radio Engineering. Second Edition (Revised). By H. I. F. Peel. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 13s. 6d.

Apprenticeship (An Enquiry into its Adequacy under Modern Conditions). By Kate Liepmann. Routledge and Kegan Paul, Ltd., Broadway House, 68-74, Carter Lane, London, E.C.4. Price 23s.

THE ENGINEER

Technical Contributors Section

MARCH 1960

The Surface Probe Method for Resistivity and Other Measurements

By J. P. NEWSOME, M.Sc., A.M.I.E.E., and J. A. BETTS, B.Sc.*

The article develops a general theory for this kind of electrical measurement, using the method of images; a survey of existing literature and applications which cover a wide range of engineering practice is then undertaken.

(1) Introduction

THE basis of this technique is that direct current is permitted to flow through two "point" electrodes placed on the flat surface of the material under test; measurements of potential difference are undertaken between specified points on the surface using further point electrodes. From these measurements, it is possible to determine the resistivity of the material if homogeneous; if the test material is built up of two layers, it is possible to determine the resistivities of the separate layers with details of the depth of the boundary below the surface.

It is in taking into account the varied nature of the shape and form of the test mediums which occur in practice that the problem presents an interesting example of analysis to which the method of images can be usefully applied.

(2) Theoretical Basis of the Method

2.1 *The Current Source in a Homogeneous Infinite and Semi-Infinite Conducting Medium.*—Consider a current source of I amperes at the point (O, O, O) in an infinite medium of resistivity $\rho\ \Omega m$ as shown in Fig. 1. At a radius r from the source the current density and potential gradient are given by

$$J_r=\frac{I}{4\pi r^2}\ ;\ E_r=\frac{I\rho}{4\pi r^2} \quad . \quad . \quad . \quad (1)$$

The potential difference between points P_1, P_2 distant respectively r_1, r_2 from the source, is then

$$\Delta V=\frac{I\rho}{4\pi}\int_{r_1}^{r_2}\frac{1}{r^2}dr=\frac{I\rho}{4\pi}[1/r_1-1/r_2] \quad . \quad (2)$$

Consider now the medium to be semi-infinite, extending to infinity for negative values of y and having a flat surface in the xz plane. The current distribution in a semi-infinite medium is identical with that due to two current sources, each of I amperes, operating in an infinite medium, one source being placed immediately below the point O and an image source immediately above the point O, both along the y axis. Thus, with reference to Fig. 2, ΔV is now given by

$$\Delta V=\frac{(2I)\rho}{4\pi}[1/r_1-1/r_2]=\frac{I\rho}{2\pi}[1/r_1-1/r_2] \quad . \quad (3)$$

Let now the practical case be considered of two sources, each of I amperes, but of opposite sign (arising from a single source of e.m.f. and located on the surface at O_1, O_2; it is proposed to determine the potential difference between the surface points P_1, P_2 which are located on the straight line joining O_1, O_2, as shown in Fig. 3, which is drawn in two dimensions for clarity.

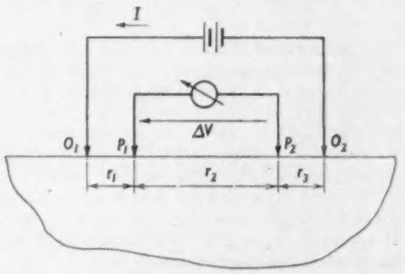


Fig. 3

Now ΔV due to source O_1 alone is given by

$$(\Delta V)_1=\frac{I\rho}{2\pi}\left[\frac{1}{r_1}-\frac{1}{(r_1+r_2)}\right]$$

and ΔV due to source O_2 alone is given by

$$(\Delta V)_2=\frac{I\rho}{2\pi}\left[\frac{1}{r_3}-\frac{1}{(r_2+r_3)}\right]$$

so that the actual value of $\Delta V=(\Delta V)_1+(\Delta V)_2$ is expressed as

$$\Delta V=\frac{I\rho}{2\pi}\left[\frac{1}{r_1}+\frac{1}{r_3}-\frac{1}{(r_1+r_2)}-\frac{1}{(r_2+r_3)}\right] \quad . \quad (4)$$

If $r_1=r_2=r_3=r$, then

$$\Delta V=\frac{I\rho}{2\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

2.2 *The Current Source on the Surface of an Infinitely Large Flat Plate of Uniform and Finite Thickness.*—Let the flat plate have parallel surfaces infinite in extent in the xz plane at $y=O$ and $y=-t$, as shown in Fig. 4 (*a*). An expression for the potential distribution due to a current source of I amperes at $O(O, O, O)$ is now evolved by summing the potentials due to a succession of image sources considered to operate in an infinite medium in the following manner.

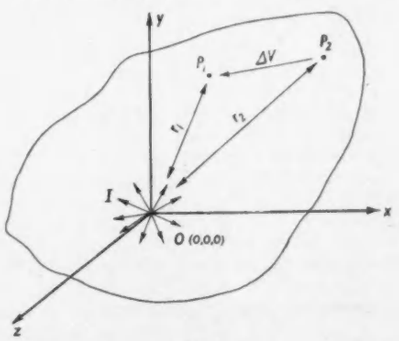


Fig. 1

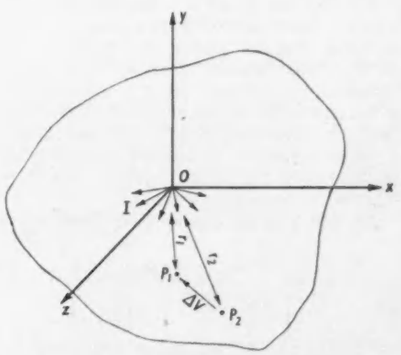


Fig. 2

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Consider the point P_1 to exist in the xz plane and to have a y co-ordinate of zero as shown in the two-dimensional diagram of Fig. 4 (*b*).

The current distribution in the plate due to the current source at O may be seen to be identical with the current distribution in an infinite medium due to current sources of $2I$ amperes at O, A, B, C.... It may be argued that the source at A is to prevent current passage beyond the boundary $y=-t$ due to the source at O, the source at B to prevent current passage beyond the boundary $y=O$ due to the source at A, and so on.

Thus, the potential at P_1 is given by

$$V_{P1}=\frac{I\rho}{2\pi}\left\{\frac{1}{OP_1}+\frac{1}{AP_1}+\frac{1}{BP_1}+\frac{1}{CP_1}+\ldots\right\}$$

$$=\frac{I\rho}{2\pi}\left\{\frac{1}{r_1}+\frac{1}{\sqrt{r_1^2+4t^2}}+\frac{1}{\sqrt{r_1^2+4t^2}}+\frac{1}{\sqrt{r_1^2+16t^2}}+\frac{1}{\sqrt{r_1^2+16t^2}}+\ldots\right\}$$

$$=\frac{I\rho}{2\pi}\sum_{n=-\infty}^{+\infty}\frac{1}{\sqrt{r_1^2+4n^2t^2}} \quad . \quad . \quad . \quad . \quad (6)$$

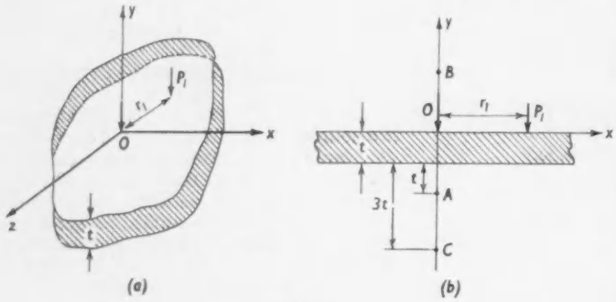

Fig. 4

The potential difference between two points P_1, P_2 on the surface of the plate, distant respectively r_1, r_2 from O, is given by

$$\Delta V=\frac{I\rho}{2\pi}\left\{\sum_{n=-\infty}^{+\infty}\frac{1}{\sqrt{r_1^2+4n^2t^2}}-\sum_{n=-\infty}^{+\infty}\frac{1}{\sqrt{r_2^2+4n^2t^2}}\right\} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

If $\alpha_1=r_1/2t$, $\alpha_2=r_2/2t$, then equation (7) may be more conveniently written thus :

$$\Delta V=\frac{I\rho}{4\pi t}\left\{\sum_{n=-\infty}^{+\infty}\frac{1}{\sqrt{\alpha_1^2+n^2}}-\sum_{n=-\infty}^{+\infty}\frac{1}{\sqrt{\alpha_2^2+n^2}}\right\} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$=\frac{I\rho}{4\pi t}\left[\left(\frac{1}{\alpha_1}-\frac{1}{\alpha_2}\right)+2\left(\sum_{n=1}^{+\infty}\frac{1}{\sqrt{\alpha_1^2+n^2}}-\frac{1}{\sqrt{\alpha_2^2+n^2}}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Consider now the practical case shown in Fig. 5 with current probes located on the surface of the plate at O_1, O_2; it is proposed to determine the potential difference, ΔV, between the surface potential probes at P_1, P_2, it being assumed that P_1, P_2 lie on the straight line joining O_1, O_2 and are symmetrically placed about those points.

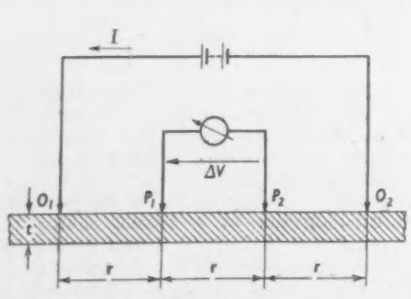

Fig. 5

ΔV, due to the source at O_1, is given by an expression similar to equation (9) except that in this case $\alpha_1=r/2t$, $\alpha_2=r/t$; thus

$$(\Delta V)_1=\frac{I\rho}{4\pi t}\left[t/r+2\left(\sum_{n=1}^{\infty}\frac{1}{\sqrt{\alpha_1^2+n^2}}-\frac{1}{\sqrt{4\alpha_1^2+n^2}}\right)\right]$$

A similar expression exists for ΔV, due to the source at O_2. The actual value of ΔV due to both sources is then

$$\Delta V=\frac{I\rho}{2\pi t}\left[t/r+2\left(\sum_{n=1}^{\infty}\frac{1}{\sqrt{\alpha_1^2+n^2}}-\frac{1}{\sqrt{4\alpha_1^2+n^2}}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Note that if $t\to\infty$, the expansion terms tend to zero and equation (10) reduces to equation (5).

2.3 *The Current Source on the Surface of a Medium of Infinite Thickness, But Finite Surface Area.*—Consider the symmetrical electrode configuration shown in Fig. 5 to approach the edge of the plate; the electrical behaviour of the system is no longer given by equation (5). Now the line of the four probes may be considered to approach the edge of the plate in a manner parallel to or at right angles to the edge as shown in Fig. 6. The correct potential distribution is obtained by considering image current sources to exist at points O_1', O_2'. Equation (5) is now replaced by equations (11) and (12), which refer respectively to Figs. 6 (*a*) and 6 (*b*).

$$\Delta V=\frac{I\rho}{2\pi r}\left\{1+\frac{2}{\sqrt{1+4\beta^2}}-\frac{1}{\sqrt{1+\beta^2}}\right\} . \quad (11)$$

$$\Delta V=\frac{I\rho}{2\pi r}\left\{1+\frac{1}{(1+2\beta)}-\frac{1}{(2+2\beta)}+\frac{1}{(5+2\beta)}-\frac{1}{(4+2\beta)}\right\} \text{ where } \beta=d/r \quad . \quad . \quad . \quad . \quad . \quad (12)$$

If the edge of the plate is made conducting, then it is necessary to derive solutions similar to those obtained above, but with the sign of the image sources reversed. The above treatment applies only when a single edge is in the proximity of the probes ; where more than one edge is adjacent to the probes, then a more complex treatment involving an infinite series of image sources would be required to obtain a solution.

2.4 *The Current Source in a Semi-Infinite Medium of Resistivity ρ_1 Bounded by a Semi-Infinite Medium of Resistivity ρ_2.*—Consider a semi-infinite medium of resistivity ρ_1 to exist for positive values of y and to have a flat surface in the xz plane at $y=O$ in intimate contact with a semi-infinite medium of resistivity ρ_2 extending to infinity for negative values of y. To develop expressions for the potentials at points P_1, P_2 in each medium due to a current source of I amperes at $O(O, y_0, O)$ consider an image source to exist at $O'(O, -y_0, O)$.

Fig. 6

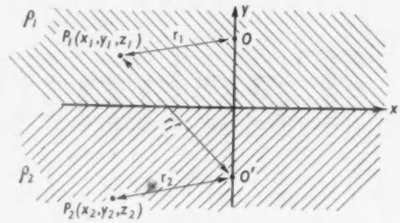

Fig. 7

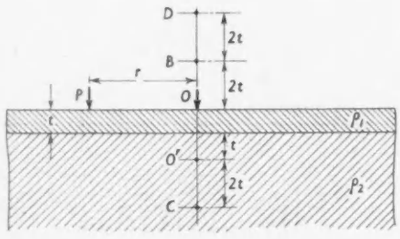

Fig. 8

Then the potentials at P_1, P_2 are given by

$$V_{P1}=\frac{A}{r_1}+\frac{A'}{r_1'}=V_{P1}'+V_{P1}''. \qquad V_{P2}=\frac{B}{r_2} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where

$$r_1^2=x_1^2+(y_1-y_0)^2+z_1^2$$
$$r_1'^2=x_1^2+(y_1+y_0)^2+z_1^2$$
$$r_2^2=x_2^2+(y_2-y_0)^2+z_2^2.$$

These expressions arise by comparison with a corresponding example in electrostatic theory.[1] Now to determine the values of A', B in terms of A :

(i) The potential of a point $P'(x, O, z)$ in the xz plane at $y=O$ can be obtained from either of equations (13) ; since $r_1=r_1'=r_2$, then $(A+A')=B$. . . . . (14)

(ii) Current density in the direction of the y axis must have the same value at the point (O, O, O) in both materials. Thus

$$\frac{1}{\rho_1}\left[\frac{\partial V_{P1}}{\partial y}\right]_{(O,O,O)}=\frac{1}{\rho_2}\left[\frac{\partial V_{P2}}{\partial y}\right]_{(O,O,O)}$$

or

$$\frac{1}{\rho_1}\left[\frac{\partial V_{P1}'}{\partial r_1}\cdot\frac{\partial r_1}{\partial y}\right]_{(O,O,O)}+\frac{1}{\rho_1}\left[\frac{\partial V_{P1}''}{\partial r_1'}\cdot\frac{\partial r_1'}{\partial y}\right]_{(O,O,O)}=\frac{1}{\rho_2}\left[\frac{\partial V_{P2}}{\partial r_2}\cdot\frac{\partial r_2}{\partial y}\right]_{(O,O,O)}$$

$$\frac{1}{\rho_1}\left[-\frac{A}{r_1'^2}\cdot\frac{2(y-y_0)}{2r_1}-\frac{A'}{r_1'^2}\cdot\frac{2(y+y_0)}{2r_1'}\right]_{(O,O,O)}=\frac{1}{\rho_2}\left[-\frac{B}{r_2^2}\cdot\frac{2(y-y_0)}{2r_2}\right]_{(O,O,O)}$$

giving

$$\frac{1}{\rho_1}(A-A')=\frac{1}{\rho_2}\cdot B \quad . \quad . \quad . \quad (15)$$

Equations (14), (15) then yield

$$B=A\frac{2\rho_2}{(\rho_1+\rho_2)} ; \quad A'=A\left\{\frac{\rho_2-\rho_1}{\rho_2+\rho_1}\right\}$$

so that equations (13) become

$$V_{P1}=A\left[\frac{1}{r_1}+\frac{k}{r_1'}\right] \quad . \quad . \quad . \quad (16)$$

$$V_{P2}=A\frac{(1+k)}{r_2} \quad . \quad . \quad . \quad . \quad (17)$$

where

$$k=\left\{\frac{\rho_2-\rho_1}{\rho_2+\rho_1}\right\}.$$

If $k=O$ then $V_{P1}=A/r_1$ and is also given by equation (2) (with $r_2=\infty$) thus making $A=I\rho_1/4\pi$. The potential of points having positive values of y would thus be given by considering the entire medium to be of resistivity ρ_1 and containing sources at O and O' of strength I and kI amperes respectively.

2.5 *The Current Source on the Surface of a Semi-Infinite Medium of Resistivity ρ_2 Having a Layer Adjacent to the Surface of Resistivity ρ_1 and Uniform Depth t.*—Let the medium enclosed between the planes $y=O$ and $y=-t$ be of resistivity ρ_1 and that enclosed between the planes $y=-t$ and $y=-\infty$ be of resistivity ρ_2. Assume a current source of I amperes at O (O, O, O). To develop the position and strength of the necessary image sources assume the medium of resistivity ρ_1 to be semi-infinite for positive values of y; the potential at P would then be given by equation (16). To meet the actual form of the medium, image sources must now be placed at O of strength A, at O' and B of strength kA, at C and D of strength k^2A, &c. The potential at P is then correctly given by

$$V_P=2A\left\{\frac{1}{r}+\frac{k}{\sqrt{r^2+4t^2}}+\frac{k}{\sqrt{r^2+4t^2}}+\frac{k^2}{\sqrt{r^2+16t^2}}+\frac{k^2}{\sqrt{r^2+16t^2}}+\ldots.\right\}$$

$$=\frac{I\rho_1}{2\pi}\sum_{n=-\infty}^{+\infty}\frac{k^n}{\sqrt{r^2+4n^2t^2}} \quad . \quad . \quad . \quad . \quad (18)$$

If the four-probe arrangement of Fig. 5 is employed, then using equation (18) the following expression is obtained for the voltage between the inner probes P_1, P_2 due to the current I amperes in the outer probes

$$\Delta V=\frac{I\rho_1}{2\pi t}\left[t/r+2\sum_{n=1}^{\infty}k^n\left(\frac{1}{\sqrt{\alpha_1^2+n^2}}-\frac{1}{\sqrt{4\alpha_1^2+n^2}}\right)\right]$$

$$. \quad . \quad . \quad . \quad . \quad (19)$$

(3) Applications of the Method

3.1 *The Measurement of the Thickness of Metal Plates from One Side Only.*—The considerable activity in this field some twenty years ago is discussed in a paper by B. M. and W. M. Thornton,[2] who developed the four-point probe method of measurement. The probe consisted of two current probes 2in to 3in apart carrying currents up to 30A between which are symmetrically placed two potential probes connected to a galvanometer; the probe points are brought into contact with the surface under test. A calibration curve of probe current against plate thickness for a fixed galvanometer deflection was required for plates having different resistivities. Steel plate and iron castings thickness up to 1in and 3in respectively was successfully measured. A calibration curve obtained by plotting the ratio of two potential readings (obtained from two sets of potential probes) for a fixed probe current against plate thickness was found to be independent of plate resistivity; this is evident from the work of Section 2.2 and also from a further theoretical paper by W. M. Thornton.[3]

The latter method was further developed by A. G. Warren,[4] who utilised a series of four-point probes, the probes being located at the corners of a square. Both papers take into account the effect of the proximity of the probe to the edge of the test plate.

3.2 *The Measurement of Semi-Conductor Material Resistivity.*—The four-point probe is found to be useful in the measurement of the resistivity of semi-conductor materials; its advantages over more conventional techniques are as follows:—(i) The test material shape can take many forms, (ii) the rectifying metal-to-semi-conductor contact can be considered to fall outside the measuring circuit, (iii) it is possible to measure the resistivity over various parts of the surface of a relatively large specimen of semi-conductor material. Semi-conductor resistivity test sets of this type are commercially available in the U.S.A. (for example, by Baird Associates, Ltd.). Details of this type of measurement are given by L. B. Valdes,[5, 6] who employs a four-point probe of the type shown in Fig. 5. Probe current is about 1mA and probe spacing 0·05in.

It is convenient to initially apply the expression for resistivity, which assumes the specimen infinite in extent, thereby determining an apparent resistivity ρ_a; thus, using equation (5)

$$\rho_a=\frac{\Delta V}{I}.2\pi r \quad . \quad . \quad . \quad . \quad (20)$$

The true resistivity ρ is then determined from ρ_a by the use of correction factors $[\rho/\rho_a]$ derived from any significant boundary conditions. The probe can be brought relatively close to an edge before $[\rho/\rho_a]$ departs significantly from unit. This is demonstrated in Fig. 9, in which are shown graphs of

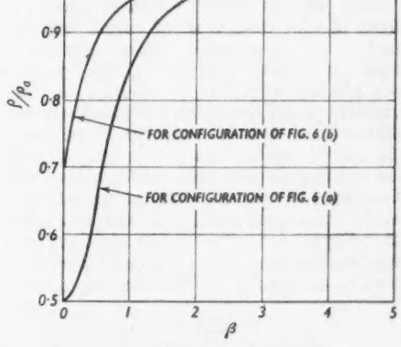

Fig. 9—Graphs of correction factor $\{\rho/\rho_a\}$ against β

$[\rho/\rho_a]$ against β for the configurations of Fig. 6.

Fig. 10 is a graph of $[\rho/\rho_a]$ against α_1; this graph indicates the correction required when dealing with thin plates. The calculation of this latter factor requires the evaluation of the slowly converging series of equation (10); this work is facilitated by the numerical tables of

$$\sum_{n=1}^{\infty}\left[\frac{1}{n}-\frac{1}{\sqrt{n^2+\lambda^2}}\right]$$

for different values of λ computed by Uhlir.[7] The papers of both Valdes and Uhlir develop additional correction factors to those quoted in the above text.

3.3 *The Measurement of Earth Resistivity.*—Geophysicists employ the four-point probe technique to assist in obtaining data on the sub-surface structure of the ground. The arrangement shown in Fig. 5 is here termed the Wenner arrangement and by taking a series of readings over an area, the probe

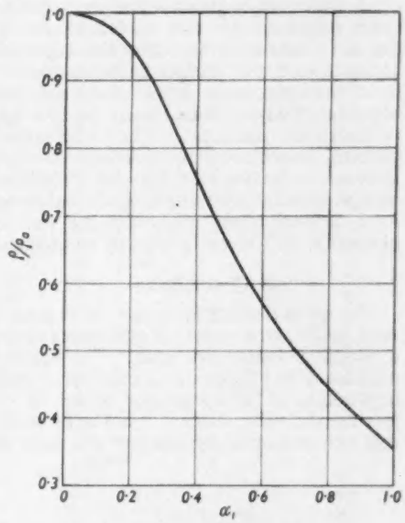

Fig. 10—Graph of correction factor $\{\rho/\rho_a\}$ against α_1

spacing remaining constant, it is possible to detect variations in the substructure of the ground over that area. To examine the structure of the ground below a given surface point, a succession of probe measurements are made with increasing electrode spacing. Should the ground consist of two layers, one of finite depth, parallel and adjacent to the surface, the other extending ideally to infinite depth, then such measurements can enable the depth of the first layer to be measured. A technique for this is developed by Tagg,[8] using a theory similar to that covered in Section 2.5 of this article; the author further gives curves for the "standard" four-point probe (of Fig. 5) of $[\rho_1/\rho_a]$ against $[t/r]$ for different values of k. In a recent resistivity survey of the area around the Wash by the same author,[9] steel electrodes ½in diameter by 15in long were used.

Other geophysical aspects of this subject are discussed in the texts of Dobrin[10] and Heiland.[11]

3.4 *The Measurement of Liquid Conductivity.*—The probe method can be used to measure liquid conductivity. Fig. 11 shows a

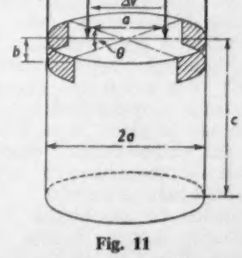

Fig. 11

system analysed by Wait[12] in which the test liquid is allowed to completely fill an insulating cylindrical beaker. Point potential electrodes at the surface of the liquid are used; the current electrodes may cover a finite, but small, area (that is, b and θ should be as small as possible).

It is shown that $\Delta V/I=\gamma/\sigma a$, where σ is the conductivity of the liquid under test; γ has the following numerical values:—

$$c=a, \quad \gamma=1\cdot0207$$

$$c=2a, \quad \gamma=0\cdot9487.$$

An alternating current source is frequently used when making this kind of measurement.

3.5 *Other Applications.*—The authors became interested in this technique as a possible method of measuring the depth of hardness in flame, surface-hardened steels; here the transition from hardened to unhardened layer differs from that in the unhardened medium. The theoretical problem would seem to be similar to that discussed in Section 2.5. Practical difficulties and the variation of resistivity in the hardened layer resulted in the method giving way to alternative and more favourable techniques.

(4) Conclusions

The surface probe technique of measurement has found a variety of applications over a period of twenty-five years. The authors considered an article covering the theory and application of this technique would be of interest and value, since it is not improbable that new industrial applications will arise in the future due to the inherent simplicity of its fundamental theory and the apparatus required to operate it.

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Limitations of the Collapse Method of Design

By W. J. SUTCLIFFE, B.Sc.(Tech.)*

The evolution of the plastic method of design for steel structures, with its adoption in practice over the past few years for the design of a number of structures, is generally considered to be one of the triumphs of British engineering research. The author is, however, sceptical of plastic design, and has grouped together in this article what he considers to be its limitations and disadvantages.

THE normal "elastic" method of design of structures aims at producing a design in which a given working stress is not exceeded. In an ideal design all the structure would be at this maximum allowable stress when the load was equal to the maximum working load. The collapse or "plastic" method of design, as advocated by Professor J. F. Baker and others, aims at producing a design in which the structure has a certain load factor against collapse. In an ideal design all the parts of the structure would collapse at the same load, but would be at (in general) varying stresses under working loads. It is claimed for this collapse, plastic or limit design method, as it is variously called, that it is more "rational," whereas those who persist in using the old elastic methods are liable to be called reactionary. The merits and advantages of the proposed new method have been published in many places and although certain limitations have occasionally been mentioned, it may be of value to attempt to bring these together, and possibly to add to them, so as to ascertain if in fact the well-established elastic design methods are by comparison so "illogical"[1] as some would have us believe.

An appraisal of the plastic method is below grouped under various headings, though some, if not all, of the points considered are to a greater or lesser degree interdependent. The order of items is not necessarily the order of their relative importance.

Alleged Advantage of Weight Saving

An account of the plastic method usually begins with an analysis of the design of a beam with fixed ends carrying a distributed load. It is shown[2] that such a beam would have a higher load factor against collapse than would a simply supported beam, if both were designed elastically to the same working stress. Hence, the argument goes, the fixed end beam could, in fact, be made lighter while still retaining an equal margin against collapse.

Now there is indeed a certain amount of truth in this, though it, of course, assumes that a constant margin against collapse is what is required. However, the question immediately arises as to whether, in fact, practical joints approach the fixed end condition. For, if there is any advantage due to the use of plastic theory, it is only because the bending moment diagram for a beam with fixed ends has greater values at the ends than at the centre in the elastic range, whereas at collapse, according to the plastic theory, the bending moment at the ends is equal to that at the centre. These bending moment diagrams are shown in Figs. 1 and 2 (q is the load factor).

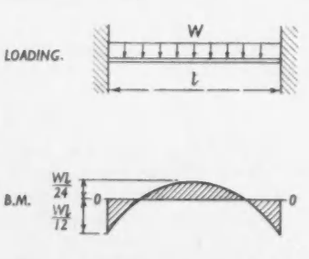

Fig. 1—Bending moment under working load

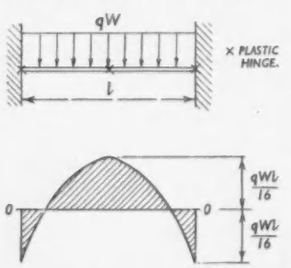

Fig. 2—Bending moment at collapse

Thus the increased load factor which the plastic theory gives, in comparison with that for a simply supported beam, is in the ratio of 16 : 12, i.e. the load factor for a fixed end beam is increased in the ratio

$$\frac{\text{Maximum bending moment produced by a factored working load}}{\text{Maximum bending moment produced by a collapse load}}$$

Reference 2 gives a complete analysis and shows that, according to British Standard 449; 1948 (working stress=10 tons per square inch), the load factor is 1·75 for a simply supported beam and 2·34 for a fixed end beam—that is 2·34/1·75=16/12. Now any practical beam must come somewhere in the range between the completely fixed end beam and the simply supported one—no fixation is completely rigid and no support completely without friction. However, whatever the end conditions, a beam carrying a uniformly distributed load must have a total vertical height of the bending moment diagram equal to $Wl/8$ (W being the total load)—the effect of different end conditions being merely to alter the position of the line of zero bending moment. Thus the bending moment diagrams for different rigidities of end fixation can be drawn, e.g. Fig. 3 shows the diagrams for

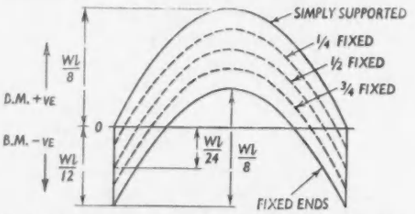

Fig. 3—Bending moment diagrams for beam carrying a uniformly distributed load. Length = l, total load = W

one-quarter, one-half and three-quarter fixed ends. Now there is no advantage of weight saving to be obtained by using the collapse design method for a simply supported beam. There is allegedly an advantage of 16/12−1 =33⅓ per cent increase in load factor for a beam with completely rigidly fixed ends, and this advantage will decrease with decreasing end constraint to reach zero when the bending moment diagram gives equal values at the ends to that at the centre, i.e. when centre bending moment=end bending moment= $Wl/16$. An end bending moment of $Wl/12$ corresponds to 100 per cent fixation, so that this condition of an end bending moment of $Wl/16$ corresponds to 75 per cent fixation.

Now if the end constraint is considered to decrease still further, e.g. to a condition of one-quarter fixed where the end moment $=Wl/48$ and the centre bending moment $=5Wl/48$, then it would appear at first sight that the collapse method of design would again give an advantage in strength/weight ratio, because for any beam where there is a redundancy and more than one plastic hinge must form before collapse takes place, the collapse method should be advantageous if the maxima on the bending moment diagram are not equal.

The standard argument for the case of a beam with completely fixed ends goes as follows. The ends have the highest bending moment and so yield will occur there first as the load is increased and then plastic hinges will form at the ends. But "collapse" does not occur until the final plastic hinge completely develops at the centre, when the ends still develop their full plastic moment. One would therefore think that the collapse of a beam with one-quarter fixed ends would proceed likewise. Yield would occur first at the centre where there is the highest bending moment (assuming uniform cross section, of course). As the load was further increased a plastic hinge would form at the centre, but

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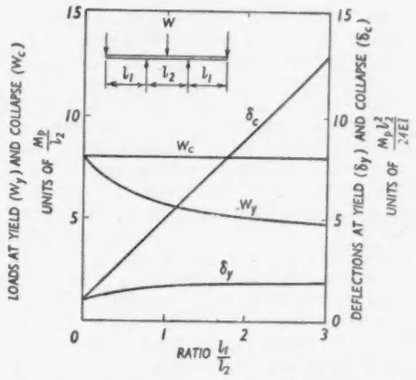

Fig. 4—Strength and central deflection of beam on four supports carrying a concentrated load

" collapse " would not occur until the final plastic hinges developed at the ends, when the centre would be still supplying its full plastic moment.

Now this is rather odd. In the first place the deflection at collapse for the quarter-fixed case will be much greater than for the completely fixed beam and, further, it will be seen that if the rigidity of the end fixing is decreased still more, the deflection at " collapse " will become greater and greater and as the condition approaches the simply supported case, the deflection at " collapse " approaches infinity ! Furthermore, the collapse load is apparently the same whatever the end conditions and however near the end constraint approaches the simply supported condition : which is clearly in violent contradiction with the normal derivation from the plastic theory that the collapse load for a simple supported beam compared to that for a fixed end beam is in the ratio

$$\frac{qWL^2}{16} \cdot \frac{qWL^2}{8} = 1 : 2.$$

Figs. 4, 5, 6 and 7 show how, according to the two theories, the strength and deflection of beams vary as the end fixation is varied. Fig. 4 gives the graphs for a concentrated load W on a beam of length l_2, the end fixation being varied by varying the ratio l_1/l_2.

$l_1/l_2=0$ corresponds to the fixed end case.

W_c is the load at collapse and W_y the load at " yield "—which is taken here to mean the load at which the initial linear load/(central deflection) relationship ends, i.e. when the first plastic hinge has just completely formed. This occurs when the value of the maximum bending moment, at the point where the plastic hinge forms, equals M_p, the plastic moment of resistance of the beam section.

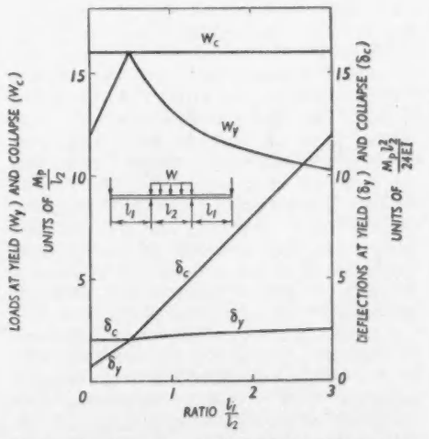

Fig. 5—Strength and central deflection of beam on four supports carrying a uniformly distributed load

M_p = bending moment at which yielding just occurs throughout the depth.
= bending moment to cause yield at outer fibres × shape factor.
= yield stress × second moment of area of beam section × $\frac{\text{shape factor for the beam section}}{\text{maximum fibre distance from the neutral axis.}}$

δc and δy are the central deflections corresponding to the loads W_c and W_y respectively.

Fig. 5 deals in a similar manner with the case where the central span carries a uniformly distributed load. In Figs. 6 and 7 the quantities plotted in Figs. 4 and 5 are redrawn on a base of percentage end fixation—the moment at a completely rigid support is taken as 100 per cent. The loads at the end of linearity and at collapse are here plotted as a percentage of the collapse load according to the plastic theory—this load does not vary with end fixation. These loads and deflections correspond to the strengths and deflections of a beam considered on the plastic and elastic design theories.

The formulæ, from which these graphs are plotted, can be derived by normal methods such as the moment-area method or the Myosotis method. W_y and δy are thus obtained and W_c and δc then derived by considering the collapse mechanism in a manner shown by Neal,[1] pages 40 to 45. The formulæ are :

For a concentrated load acting at the centre of a beam over four supports (Fig. 4) :

At yield :

$$W_y = \frac{8M_p}{l_2}\left[\frac{2l_1+3l_2}{4l_1+3l_2}\right]$$

$$\delta y = \frac{M_p l_2^2}{24EI}\left[\frac{8l_1+3l_2}{4l_1+3l_2}\right].$$

At collapse :

$$W_c = \frac{8M_p}{l_2}, \quad \delta c = \frac{M_p l_2}{24EI}(4l_1+l_2).$$

For a uniformly distributed load acting on the central span of a beam over four supports (Fig. 5).

Case α—first plastic hinges forms at supports :

$$\left(\frac{l_1}{l_2}=0 \text{ to } \tfrac{1}{2}\right).$$

At yield :

$$W_y = \frac{M_p}{l_2^2}(8l_1+12l_2)$$

$$\delta y = \frac{M_p l_2}{96EI}(10l_1+3l_2).$$

At collapse :

$$W_c = \frac{16M_p}{l_2}, \quad \delta c = \frac{M_p l_2^2}{12EI}.$$

Case β—first plastic hinge forms at centre of beam :

$$\left(\frac{l_1}{l_2}=\tfrac{1}{2} \text{ to } \infty\right).$$

At yield :

$$W_y = \frac{8M_p}{l_2}\frac{(2l_1+3l_2)}{(2l_1+l_2)}$$

$$\delta y = \frac{M_p l_2^2}{48EI}\frac{(10l_1+3l_2)}{(2l_1+l_2)}.$$

At collapse :

$$W_c = \frac{16M_p}{l_2}, \quad \delta c = \frac{M_p l_1 l_2}{6EI}.$$

$$\text{Percentage fixation} = \frac{3\times 100}{2\frac{l_1}{l_2}+3}.$$

This is, of course, the same for both types of loading, as it is a function of the rigidity of the end fixation only. Referring to Fig. 6 (concentrated loading), it can be seen that the plastic theory gives no advantage of strength when its ends are completely fixed, but does give an advantage with less rigid supports, although the corresponding collapse deflection soon becomes ridiculously large. For the distributed load case, the interesting point, shown in Fig. 7, is that the strength

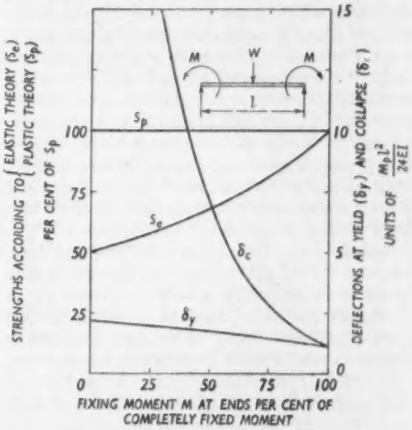
STRENGTHS ACCORDING TO { ELASTIC THEORY (S_e) / PLASTIC THEORY (S_p) } PER CENT OF S_p
DEFLECTIONS AT YIELD (δ_y) AND COLLAPSE (δ_c)
UNITS OF $\frac{M_p l^2}{24EI}$
M W M
l
S_p
S_e
δ_c
δ_y
FIXING MOMENT M AT ENDS PER CENT OF COMPLETELY FIXED MOMENT

Fig. 6—Strength and deflection of beam with concentrated load and varying end fixation

of the beam on the elastic theory is equal to that given by the plastic theory at 75 per cent fixation but decreases as the end rigidity is increased or decreased.

The plastic theory normally uses the apparent strength advantage in the fully fixed condition, but the greater theoretical advantage of lesser fixations than 75 per cent is not considered : though, of course, the collapse deflections become very large—approaching infinite values as the fixation decreases to zero.

In fact, the strength of a simple supported beam, i.e. one of 0 per cent fixation, is normally considered in plastic design to be the same as the elastic strength, i.e. half the plastic strength for a fixed end beam. This paradox is mentioned by B. G. Neal,[1] who

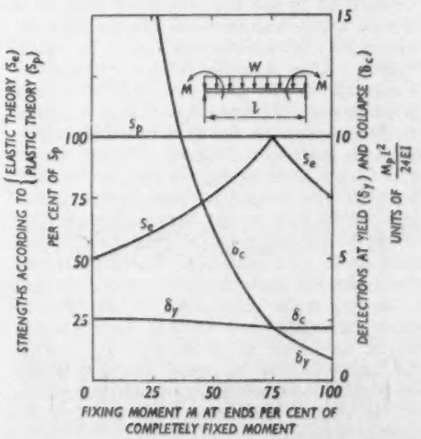

Fig. 7—Strength and deflection of beam with distributed load and varying end fixation

says (pages 51 to 52) : " However, this apparent paradox, which was pointed out by Stussi and Kollbrunner, is resolved when it is realised that the horizontal load-deflection relation which occurs in this case, when $W=W_y$ " (case of simply supported beam) " is merely the limiting case in which the slope of the load-deflection relation between yield and collapse tends to zero as l_1 tends to infinity " (as fixation decreases to zero).

It is difficult to see how this paradox is in

any way resolved by this, which seems to be merely a re-statement of it. The paradox remains real rather than apparent.

It can be concluded from Fig. 7 that the alleged strength advantage according to the plastic theory can only arise, even theoretically, if the beam end fixation is very rigid indeed. Now, the rigidity which counts in this matter is not the rigidity of the actual riveted or welded connections at the ends but the rigidity of these connections, combined with that of the members to which the beam is fixed. In the case of a steel-framed building the stanchions are usually of a less section than the cross-beams so that the equivalent ratio I_1/I_2 is likely to be half or more. Therefore the overall flexibility of the end constraint is likely to be greater than that at which any advantage due to plastic theory may be obtained. A point in favour of the plastic method however, is that, as shown in Figs. 5 and 7, the deflection between $I_1/I_2=0$ and $\frac{1}{2}$, is constant. The conclusion is then, that it is not so much that plastic theory gives a theoretically greater strength for a beam as normally used in a building, but that the true strength on the elastic theory is rather greater than it is normally taken to be.

The Use of Plastic Theory for the Design of Structures

The design of steel-framed buildings, for which up to the present the plastic methods have been chiefly proposed, normally utilises joists of uniform cross section. That means that the section used must be strong enough to withstand the greatest moment which occurs anywhere in a member. Therefore, as the bending moment usually varies greatly over the length of the member much of the member is of a larger section than is required and the whole member uses much more steel than is necessary.

This is unlike, say, an aircraft wing spar where the section is varied as exactly as possible in accordance with the varying bending moments along the spar. Here, however, expense is of secondary importance and weight saving paramount. For a steel-framed structure it is normally less expensive to have more steel, using uniform section joists, than to use less weight of steel, in a design using members of varying section, where the fabrication costs will be much higher. Thus it seems that in structures, which are in any case designed from such practical considerations, any change in design method seems to be hardly worth while, unless it leads to a radically different design and a very great saving in weight. In fact, however, the designs of steel-framed buildings which have so far been undertaken or proposed according to the plastic theory are such as to give maximum working stresses which are less than the yield stress. So that a design made according to the plastic theory, if stressed according to elastic theory, would be found to be satisfactory, though the safety factors for some members would be slightly lower than they would have been if the design had been from the first by elastic methods.

So that a design using the plastic method is likely to prove satisfactory and to save steel ; but only at the expense of reducing the safety factors against yield. Now the whole question of what a suitable safety factor should be, is a matter of judgment based on experience of previous designs. The plastic theory may give some theoretical justification for reducing the safety factors used for some types of members but as a method of saving weight it seems questionable. For whether a design is (*a*) according to elastic theory using current safety factors ; (*b*) according to plastic theory giving some weight saving over (*a*), or (*c*) according to elastic theory with reduced safety factors to give the same weight saving as (*b*), the structure will serve its purpose satisfactorily.

The alleged advantage of weight saving therefore appears to be to a high degree metaphysical—there being no knockdown (*sic*) practical test by which the merits of elastic and plastic methods can be compared, as structures designed on either would be satisfactory. Any weight saving being at the expense of safety factors, this could clearly go too far and in this matter it is best to err on the safe side.

The Concept of Collapse

Against the above conclusion it may be said that the plastic method aims at giving a uniform margin of strength against some condition called collapse, whereas the elastic method aims at giving a margin against yield and yield is to a degree an unreal condition, based on assumptions which are not valid, e.g. the yield point varies with work hardening and, due to force fit of members, &c., yield may be reached locally at joints before external loading is applied.

Unfortunately the concept of collapse seems to be at least as vague and to assume at least as much as the concept of yield. In the first place whether or not the material in a structure reaches the yield point it certainly should never, never reach collapse. A building, above all things, should never be imagined collapsing, one would have thought. So why so much emphasis on a condition which should never be reached ? The reply must be that abnormal loading might cause collapse, but what is abnormal loading ? Surely the safety factors should be sufficient to prevent collapse under abnormal loads of a first order. If pressures due to bomb blasts or forces due to earthquakes are to be considered then other factors immediately arise.

Suppose, for instance, a structure was designed to withstand certain dead and live vertical loads due to gravity together with certain combinations of load due to wind pressure. Now plastic design methods would attempt to give a constant load factor against collapse due to these loading conditions. That is to say the structure would be visualised as collapsing if the loads were increased by the load factor, but so far as wind is concerned this should never happen (unless the design is only to have a certain probability of not collapsing). If this pressure was imagined as caused by a bomb blast then it would not appear obvious why the distribution of pressure and the load conditions generally should be the same as those due to an impossibly increased wind. At the least, it would appear that the difference of loading in any collapse case would be at least as great as any variations of relative strength of the members due to the different design methods.

A simple definition of the collapse of a structure would be that it is the condition reached when the deflection will continue to increase without further increase of load. Now even in the case of a beam on its own, the deflection when plastic hinge(s) have formed is liable to be so large that it could hardly be considered satisfactory, even before reaching the full plastic load. For all the surrounding plaster, masonry and concrete would have broken and the loading might well have changed owing to the deflection. In the case of a live gravity load it might slide to the centre of the beam ! In the case of a single member under load due to wind pressure, even neglecting previous remarks concerning bomb blast, the deflection would change the angle of walls exposed to wind pressure so much that the aerodynamic load would alter greatly, assuming that the walls did not collapse themselves. But of course this would probably not be so, for the concrete of the walls, windows, &c., would crack long before the collapse deflection of the steel skeleton was reached. Indeed if one imagines a normal type building loaded by more and more wind pressure it seems difficult to see how the skeleton could ever collapse in the meaning as defined according to plastic theory. For long before collapse deflection of the skeleton was reached the walls on which the air pressure acts would crack away leaving the skeleton, which having little air resistance would remain " uncollapsed." The same argument to some extent applies to load due to factored gravity loading. The floor surface might crack and cease to be able to transmit an excessive live load to the cross-beams. The load would then presumably fall through to the lower floors so relieving the load on the cross-beams before collapse was reached.

If an excessive gravity load was applied directly to one cross-beam it might collapse but has the whole structure then reached collapse? Clearly not, for the plastic theory demands full plastic hinges to develop at sufficient places to establish a " collapse mechanism," i.e. so that the structure functions as a jointed mechanism. Collapse of one member without the establishment of a collapse mechanism, can be fairly termed a local failure. But in a frame of any complexity this is liable to become ridiculous. How many local failures can be tolerated before it can be said that " collapse " of the whole structure has been reached ? The conclusion appears to be that " collapse " of a steel-framed building is an unreal condition because local failures of walls, floors and beams, to which factored loads might be directly applied, would occur before the the structure as a whole could be loaded sufficiently to establish a collapse mechanism. Of course it is completely unreal to consider dead loads, due to weight of the structure itself, to be increased to assist in causing collapse. Unless of course, the structure is intended for use on another planet !

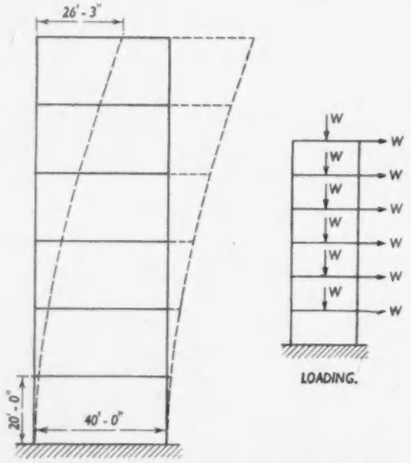

Fig. 8—Sidesway at collapse due to given loading acting on six-storey building

An effect of change of load due to deflection is illustrated in Fig. 8. An imaginary six-storied building is loaded due to gravity and sideways wind pressure. Supposing that the structure consists of, in effect, six portal frames, one on top of the other, an estimate of the sideway of the structure at collapse

can be obtained from the sidesway of a single portal frame. Full-scale tests have been carried out at Cambridge[3], pages 81–85. The horizontal deflections of a portal frame 16ft span and 8ft high were measured at collapse to be of the order of 6in. Now assuming that the deflections of the frames of the structure shown in Fig. 8 are proportionately the same as this, a 20ft frame will deflect $\frac{20}{8}\times\frac{1}{2}=1{\cdot}25$ft. Furthermore, if the slopes at the tops of the frames due to loading are assumed to be cumulative and each frame has the same deflection, then the total sidesway can be calculated. Of course, the lower frames have greater resultant loads but then they will be of correspondingly greater section and rigidity.

Now the exact loading given might not produce exactly the same sidesway in all frames but some loading of this type would, in which case the sidesway at the top of the structure would be 26·25ft on these assumptions. In this estimate the slope at the top of a frame is considered as if the stanchions remained straight and hinged about their bases. This appears reasonable from the photographs of collapsed frames (e.g.[3] Fig. 5. 36) and is likely to be less than the actual change of slope. It is immediately obvious that long before collapse was reached the wind pressure would alter and the offset of the gravity loading at the top would produce large bending moments at the base. Collapse would in fact be reached at a less deflection than that shown. Whether the plastic theory could be modified to take such factors into account is not obvious, though it would be a very difficult proceeding, but in any case it hardly seems worth while, as the concept of collapse is seen to be too extreme.

Of course the above argument makes enormous assumptions and simplifications and it would be better to determine accurately the collapse deflection of an actual structure by calculation or preferably by test. However, the very vagueness of the collapse concept makes calculation well-nigh impossible and, although crude, the approximate estimate does make one wonder what, for instance, the Empire State Building would look like in a state of collapse.

The nearer a design becomes perfect, i.e. so that the whole structure becomes plastic at the same load, the greater would be the deflection at collapse. If a cantilever was tapered exactly in accordance with the bending moment at all sections then the whole length would theoretically become plastic at the same load. The angular rotation of the normally assumed plane section at any point along the beam could not in any case be theoretically calculated, because, for the fully plastic moment to develop, infinite rotation at the hinge is required. However, it is alleged that in practical tests plastic hinges do develop, where a small increase in bending moment produces very large rotations. However, if these rotations occur all along an ideally designed beam, the resulting total deflection will be huge indeed.

There are a number of separate reasons why the deflection of a beam at collapse may theoretically be infinite :

(*a*) Due to the fact that there cannot be any strain at the neutral axis, a plastic hinge can never form completely with finite hinge rotation.

(*b*) If the stress strain curve for the beam material is not parallel with the axis of strain after yield, the load/deflection curve for a beam will tend to a collapse load rather than reaching it.

(*c*) If a plastic hinge forms at a joint where the shearing force is zero and, therefore, the bending moment is constant, the plastic hinge forms over a finite length of beam. This is for a constant section beam.

If the section is varied in accordance with the applied bending moment, as mentioned previously, the whole beam becomes plastic at once. Thus the " better " a design, in that the structure is of uniform strength against collapse, the greater will be the collapse deflection, e.g. for the structure of Fig. 8 if the lowest frame was weak and failed completely first, then the deflection at collapse would be much less than that shown. The given deflection in fact assumes that all the frames collapse at the same load : at which condition it is surely intended to aim. The extreme paradox could be imagined where the structure of Fig. 8 might have a theoretical collapse load which was independent of strengthening of the lower frames. Suppose the structure was of uniform section throughout. Failure under increasing loading would occur in the lowest frame at some load. If now the strength of the lower frames was increased to give simultaneous collapse of all frames, then the resulting sidesway at collapse might well give the strengthened structure a collapse " strength " which was no greater than that of the original uniform frame.

Alleged Ease of Design Calculations

Owing to such facts, that the plastic design strength of a beam is independent of the end constraint, of the effects of sinking of supports and of residual stresses and stresses due to assembly, it is, therefore, said that the calculations required to design by this method are easier. These points possibly give backing to any assumptions that the effect of sinking supports, &c., can be ignored in elastic design. However, once beams and possibly portal frames are left, the application of plastic design methods to complex structures seems anything but simple. The establishment of various collapse mechanisms and strength under various loadings seems difficult if not impossible.

Analysis of a structure by strain energy, moment distribution and slope deflection methods may be difficult but it is not clear that the plastic methods are any easier. (The fact that the principle of superposition cannot be applied in a plastic analysis does not help.) For steel-framed buildings the high safety factors, inexact knowledge of loading and other practical factors make the use of assumptions and simplifications wiser in most cases. For it is liable to be a case of trying to cut firewood with a surgeon's scalpel. This is not to say that more exact methods of design are never to be aimed at or can never be successfully and usefully used.

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[2] British Constructional Steelwork Association, *The Collapse Method of Design*, Publication No. 5, 1952.
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Plastic Instability in Tension

By P. B. MELLOR, B.Eng., Ph.D.*

The condition for instability under biaxial tension is considered for materials whose strain-hardening characteristics can be fitted by the empirical equation $\bar{\sigma}=A(B+\bar{\varepsilon})^n$. *The argument is limited to stress systems arising from the application of a single load or two equal loads. Experimental values of the instability strains for the forming of a circular blank by fluid pressure are shown to be in good agreement with the theoretical treatment by Hill.*

(1) Introduction

In the simple tensile test the ultimate tensile strength, defined as the ratio of maximum load to original cross-sectional area, is given significance for acceptance purposes. At the maximum load point the strain ceases to be uniform, the specimen begins to " neck " down, and the process is said to become unstable.

If P is the load, A the current cross-sectional area and l the current length, then the true stress, σ, is given by

$$P=\sigma A \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Neglecting the small elastic change in volume the material may be assumed to be incompressible and

$$A_0 l_0=Al \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where A_0 is the original cross-sectional area and l_0 the original gauge length.

At the maximum load, $dP=0$ and from equation (1)

$$\sigma dA+Ad\sigma=0 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Also, from the condition for constancy of volume, equation (2)

$$ldA+Adl=0 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

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Thus from the last two equations

$$\frac{d\sigma}{\sigma}=\frac{dl}{l}=d\varepsilon.$$

The logarithmic strain

$$\varepsilon=\int\frac{dl}{l}=ln(1+e),$$

where e is the longitudinal engineering strain.

At the maximum load therefore

$$\frac{d\sigma}{d\varepsilon}=\frac{\sigma}{1} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If the true stress σ is plotted against the logarithmic strain, ε, the true stress at instability is found by drawing a tangent to the (σ, ε) curve such that the length of the subtangent is unity along the strain axis, Fig. 1. The corresponding strain at instability in the tensile test is then known.

Similar instability conditions can arise under more complex stress systems and in each case this condition marks the end of general straining and the inception of local " necking." It is important to remember that the U.T.S. is nothing more than the nominal stress at instability in uniaxial tension. Because of this it may be expected that the value of the instability stress varies with the stress system and the geometry of the structure. In all cases the point of

instability is defined by the maximum load condition.

Instability is of importance in the forming and pressing of sheet metals since it limits the amount of thinning that the material can withstand. The following work is confined to the straining of sheet metal under biaxial

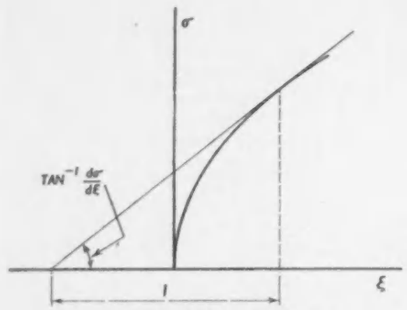

Fig. 1—Point of instability ; simple tension

tension, the third stress (normal to the sheet) is either zero or negligible in all the cases considered.

In order to make the results obtained for the different operations strictly comparable it is necessary to adopt a concept of a generalised stress-strain relation. Sachs and Lubahn (1946) used a simplified relation between the largest true principal stress and the largest absolute value of the logarithmic strain. This is not very convenient in a general argument since the " decisive strain " is then either ε_1 or ε_2 depending on whether the intermediate principal strain ε_2 is positive or negative. In the following a generalised stress-strain relation consistent with the Mises criterion of yield for an isotropic material is used. The same relation, differing only by a constant, was used by Swift (1952). In both the above papers it was assumed that the ratio between the stresses could have any given value which remained constant during the straining. However, it seems probably that under any loading conditions the stress ratio $x=\sigma_2/\sigma_1$ varies during the straining unless it has the values zero, half or unity.

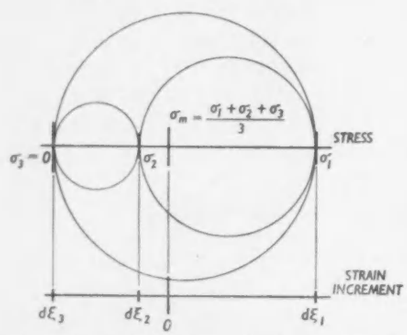

Fig. 2—Mohr circle diagram for stress and strain increment

The equations defining generalised stress, $\bar{\sigma}$, and strain $\bar{\varepsilon}$, for a rigid work-hardening material, may be written

$$\bar{\sigma}=\sqrt{\tfrac{1}{2}}\{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\}^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$d\bar{\varepsilon}=\sqrt{\tfrac{2}{3}}\{(d\varepsilon_1-d\varepsilon_2)^2+(d\varepsilon_2-d\varepsilon_3)^2+(d\varepsilon_3-d\varepsilon_1)^2\}^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where σ_1, σ_2 and σ_3 are the principal stresses written in descending order, and $d\varepsilon_1$, $d\varepsilon_2$, and $d\varepsilon_3$, are the corresponding principal strain increments. (Hill 1950*a*).

The condition for constancy of volume in this notation is then

$$d\varepsilon_1+d\varepsilon_2+d\varepsilon_3=0$$

and using this expression equation (7) reduces to

$$d\bar{\varepsilon}=\sqrt{\tfrac{2}{3}}(d\varepsilon_1^2+d\varepsilon_2^2+d\varepsilon_3^2)^{\frac{1}{2}} \quad . \quad . \quad (8)$$

The constants $\sqrt{\frac{1}{2}}$ and $\sqrt{\frac{2}{3}}$ are so chosen that for uniaxial tension $\bar{\sigma}=\sigma_1$, the longitudinal stress, and $\bar{\varepsilon}=\varepsilon_1$, the longitudinal strain. Equations (7) and (8) will be applied only to systems where there is no change in straining path and therefore the incremental strains can be integrated directly.

Again, in plastic flow the relationship between stress and plastic strain increment may be expressed by the Lévy-Mises relationship

$$\frac{d\varepsilon_1}{\sigma_1-\sigma_m}=\frac{d\varepsilon_2}{\sigma_2-\sigma_m}=\frac{d\varepsilon_3}{\sigma_3-\sigma_m} \quad . \quad . \quad (9)$$

where

$$\sigma_m=\frac{\sigma_1+\sigma_2+\sigma_3}{3},$$

the mean stress.

This postulates that the strain increment is proportional to the stress deviation and implies similarity of the Mohr circle diagram for stress and strain increment, Fig. 2.

For the case of biaxial tension $\sigma_2=x\sigma_1$, $\sigma_3=0$ where x, the stress ratio, is a proper fraction.

Then

$$\frac{d\varepsilon_1}{2-x}=\frac{d\varepsilon_2}{2x-1}=\frac{-d\varepsilon_3}{1+x} \quad . \quad . \quad (10)$$

Introducing the stress ratio into equations (6) and (7)

$$\bar{\sigma}=\sigma_1(1-x+x^2)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$d\bar{\varepsilon}=d\varepsilon_1\,.\,\frac{2}{2-x}(1-x+x^2)^{\frac{1}{2}} \quad . \quad . \quad (12)$$

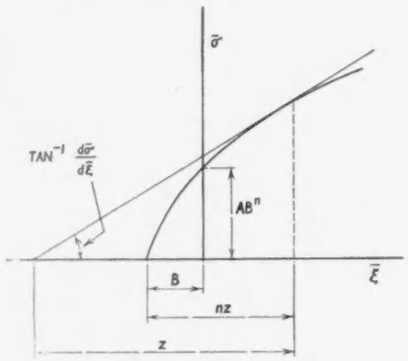

Fig. 5

and from equations (10) and (12) the general relationship between the incremental strains and stresses may be written

$$\frac{d\bar{\varepsilon}}{2(1-x+x^2)^{\frac{1}{2}}}=\frac{d\varepsilon_1}{2-x}=\frac{d\varepsilon_2}{2x-1}=\frac{-d\varepsilon_3}{1+x} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

In the following work only cases where the stress ratio can be shown to remain constant will be considered so that the last equation may be integrated to give the total strains.

$$\frac{\bar{\varepsilon}}{2(1-x+x^2)^{\frac{1}{2}}}=\frac{\varepsilon_1}{2-x}=\frac{\varepsilon_2}{2x-1}=\frac{-\varepsilon_3}{1+x} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Assume therefore that under any condition of loading, where the stress ratio remains constant, a small strain increment $d\bar{\varepsilon}$ occurs. The corresponding change in stress is, from equation (11),

$$d\bar{\sigma}=d\sigma_1(1-x+x^2)^{\frac{1}{2}} \quad . \quad . \quad . \quad (15)$$

(2) Empirical Relation to a Strain-Hardening Characteristic

A useful expression for the strain-hardening characteristic of a metal is $\bar{\sigma}=A(B+\bar{\varepsilon})^n$, suggested by Swift (1952), which for a fully annealed material reduces to the more widely used relation $\bar{\sigma}=A\bar{\varepsilon}^n$. A is some measure of the basic strength of the material, independent of its initial state, B gives an indication of the initial state of the material and n is a measure of the rate of hardening with strain.

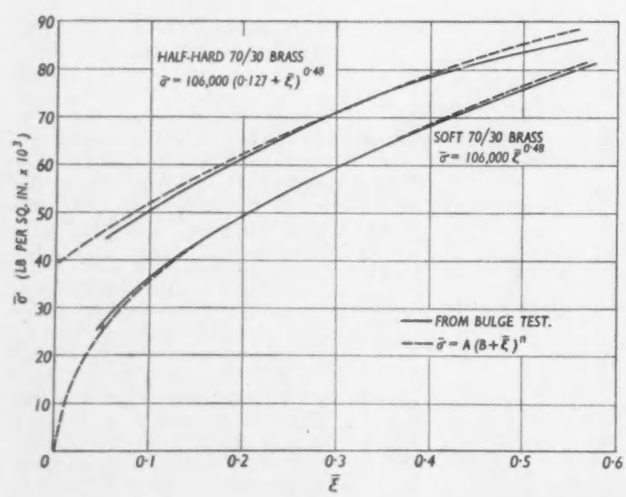

Fig. 3

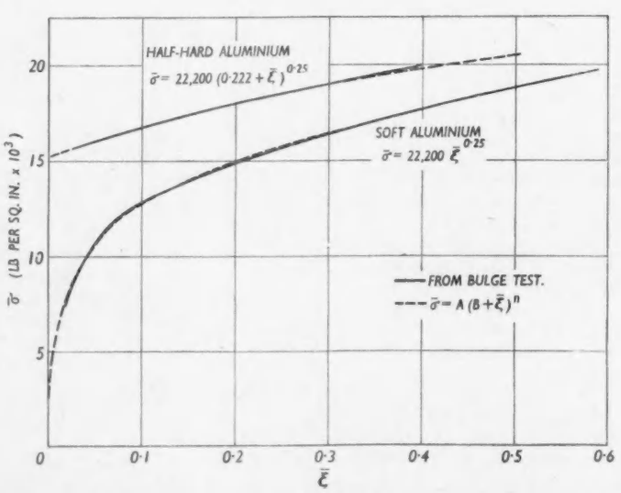

Fig. 4

TABLE I

Metal	$\bar{\sigma}=A(B+\bar{\varepsilon})^n$ (Pounds per square inch)	Experimental thickness ratio		Theoretical thickness ratio (Hill)
		Instability t/t_0	Fracture t/t_0	t/t_0
Copper, soft	$\bar{\sigma}=62{,}200\,(0{\cdot}016+\bar{\varepsilon})^{0{\cdot}3}$	0·555	0·50	0·563
Copper, half-hard	$\bar{\sigma}=62{,}200\,(0{\cdot}114+\bar{\varepsilon})^{0{\cdot}3}$	0·59	0·58	0·581
Brass, soft	$\bar{\sigma}=106{,}000\bar{\varepsilon}^{0{\cdot}65}$	No instability	0·50	0·498
Brass, half-hard	$\bar{\sigma}=106{,}000\,(0{\cdot}127+\bar{\varepsilon})^{0{\cdot}65}$	No instability	0·51	0·518
Aluminium, soft	$\bar{\sigma}=22{,}200\bar{\varepsilon}^{0{\cdot}35}$	0·565	0·48	0·580
Aluminium, half-hard	$\bar{\sigma}=22{,}200\,(0{\cdot}222+\bar{\varepsilon})^{0{\cdot}35}$	No instability	0·65	0·613
Killed steel	$\bar{\sigma}=91{,}000\bar{\varepsilon}^{0{\cdot}3}$	0·57	0·48	0·603
Stainless steel	$\bar{\sigma}=222{,}000\,(0{\cdot}016+\bar{\varepsilon})^{0{\cdot}3}$	0·52	0·50	0·487

The fit of this empirical relation to two sheet materials, 70/30 brass and commercially pure aluminium, is shown in Figs. 3 and 4. Formulæ for other sheet materials are set down in Table I. The value of the strain-hardening index, n, for commercially used materials lies between 0·2 and 0·5. The strain-hardening characteristics were obtained in balanced biaxial tension from measurements taken on the dome of a circular membrane clamped at the edges and subjected on one side to oil pressure (Mellor, 1956).

Differentiating the above formula,

$$\frac{d\bar{\sigma}}{d\bar{\varepsilon}}=\frac{n\bar{\sigma}}{(B+\bar{\varepsilon})}=\frac{\bar{\sigma}}{z}$$

where the subtangent

$$z=\frac{B+\bar{\varepsilon}}{n} \quad . \quad . \quad . \quad . \quad . \quad (16)$$

(See Fig. 5.)

The value of A does not affect the amount of strain that a material can withstand, but it does, of course, affect the stress required to attain any given value of strain.

(3) (i) Balanced Biaxial Tension

Consider a biaxial tension applied through two differing tensile forces, which remain unaffected by the local strain increments, $d\varepsilon_1$, and $d\varepsilon_2$. Then $d\sigma_1/\sigma_1=d\varepsilon_1$, and $d\sigma_2/\sigma_2=d\varepsilon_2$. If the stress ratio is to remain constant $d\sigma_1/\sigma_1=d\sigma_2/\sigma_2$, which is satisfied if $d\varepsilon_1=d\varepsilon_2$ that is, if $x=1$. Therefore, for the case of balanced biaxial tension (two equal loads) the total strains can be obtained by direct integration.

The point of instability is given by

$$d\sigma_1=\sigma_1 \,.\, d\varepsilon_1,$$

or from equation (15), putting $x=1$,

$$d\bar{\sigma}=\sigma_1 \,.\, d\varepsilon_1.$$

Again, from equations (11) and (13) $\bar{\sigma}=\sigma_1$, and $d\bar{\varepsilon}=2d\varepsilon_1=2d\varepsilon_2=-d\varepsilon_3$, and at instability,

$$\frac{d\bar{\sigma}}{d\bar{\varepsilon}}=\frac{\sigma}{2}.$$

A construction similar to that for uniaxial tension can be employed to locate the point of instability. For the present case the subtangent $z=2$, as shown in Fig. 6. The values of generalised stress and strain at instability are then known and hence, their principal components may be found.

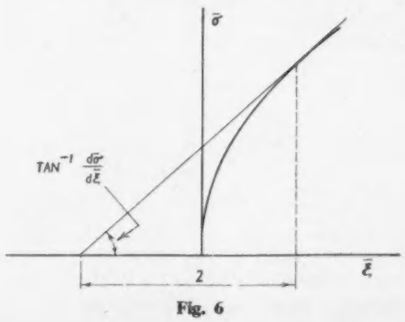

Fig. 6

The instability strains can now be compared for uniaxial and balanced biaxial tension in terms of the relation $\bar{\sigma}=A(B+\bar{\varepsilon})^n$. From equation (16) the generalised instability strain is given as $\bar{\varepsilon}=nz-B$, and for balanced biaxial tension therefore the surface strains at instability are $\varepsilon_1=\varepsilon_2=\frac{1}{2}(2n-B)$ and the thickness strain $-\varepsilon_3=2n-B$. For uniaxial tension the longitudinal strain $\varepsilon_1=n-B$ and $-\varepsilon_2=-\varepsilon_3=\frac{1}{2}(n-B)$. A comparison is made in Fig. 7 of the maximum principal strains obtaining in either case for different values of the constants n and B. The maximum principal strains are plotted in preference to the generalised strains since it is thought that they give a better mental picture of the physical process. It is seen that the maximum principal strain in biaxial tension, the thickness strain, for any given material is much greater than the maximum strain in uniaxial tension. The greater the value of n and the smaller the value of B, the greater is the strain at instability. Negative values of these strains merely indicate that instability arises before any general elongation or thinning has occurred.

The stress at instability is independent of the constant B—that is, it is independent of the initial state of the material. In particular, the instability stresses for two tempers of the same material are identical though the instability strains may, of course, be very different. A summary of the above results is given in Table II.

(3) (ii) Thin-Walled Cylinder, with Closed Ends, Subjected to Internal Pressure

If p is the internal pressure, the hoop stress $\sigma_1=pr/t$ and the longitudinal stress $\sigma_2=pr/2t$, where r and t are the current values of cylinder radius and wall thickness respectively. The stress ratio $x=\frac{1}{2}$ and at instability $dp=0$,

$$\frac{d\sigma_1}{\sigma_1}=\frac{d\sigma_2}{\sigma_2}=\frac{dr}{r}=\frac{dt}{t}$$

where dr/r is the hoop strain increment $d\varepsilon_1$ and dt/t is the incremental thickness strain $d\varepsilon_3$.

The values of generalised stress and strain are from equations (11) and (13).

$$\bar{\sigma}=\sqrt{3}/2\sigma_1$$

$$d\bar{\varepsilon}=2/\sqrt{3}\,.\,d\varepsilon_1=-2/\sqrt{3}\,.\,d\varepsilon_3 \text{ and } d\varepsilon_2=0.$$

This is a case of plane strain, the strain in the longitudinal direction being zero. It is also assumed, of course, that the end effects are local and can be neglected in the discussion.

From equation (15) $d\bar{\sigma}=\sqrt{3}/2\,.\,d\sigma_1$, and the condition at instability may be written

$$d\bar{\sigma}=\sqrt{3}/2\,.\,\sigma_1(d\varepsilon_1-d\varepsilon_3)$$

which in terms of generalised stress and strain reduces to

$$\frac{d\bar{\sigma}}{d\bar{\varepsilon}}=\sqrt{3}\bar{\sigma}$$

giving the value of the sub-tangent $z=1/\sqrt{3}$.

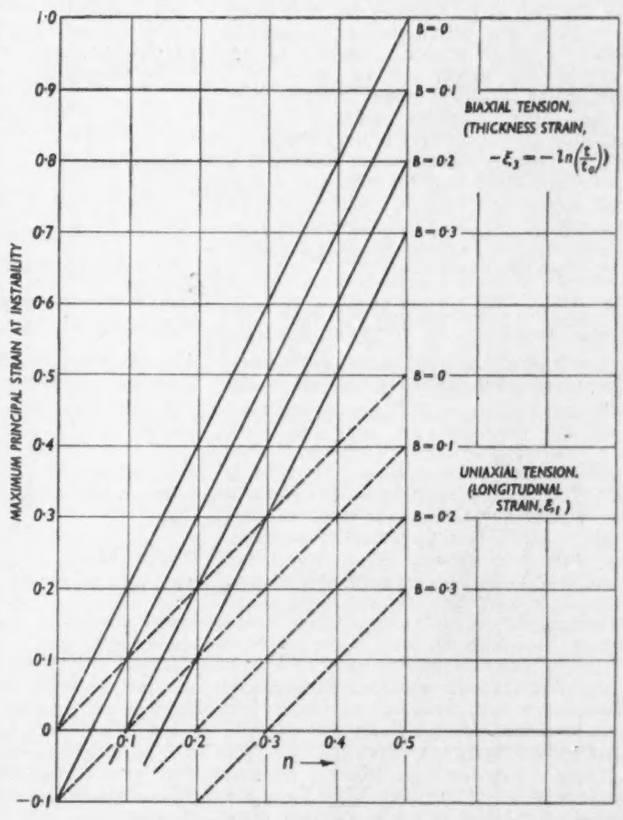

Fig. 7

TABLE II—*Summary of Results*

Loading system	$\bar{\varepsilon}$	ε_1	ε_2	$\varepsilon_3=\ln\left(\frac{t}{t_0}\right)$	$\frac{\bar{\sigma}}{A}$	$\frac{\sigma_1}{A}$	$\frac{\sigma_2}{A}$	x
Simple tension	$(n-B)$	$(n-B)$	$-\frac{1}{2}(n-B)$	$-\frac{1}{2}(n-B)$	$(n)^n$	$(n)^n$	0	1
Balanced biaxial tension	$(2n-B)$	$\frac{1}{2}(2n-B)$	$\frac{1}{2}(2n-B)$	$-(2n-B)$	$(2n)^n$	$(2n)^n$	$(2n)^n$	2
Cylinder (closed ends)	$\left(\frac{n}{\sqrt{3}}-B\right)$	$\frac{\sqrt{3}}{2}\left(\frac{n}{\sqrt{3}}-B\right)$	0	$-\frac{\sqrt{3}}{2}\left(\frac{n}{\sqrt{3}}-B\right)$	$\left(\frac{n}{\sqrt{3}}\right)^n$	$\frac{2}{\sqrt{3}}\left(\frac{n}{\sqrt{3}}\right)^n$	$\frac{1}{\sqrt{3}}\left(\frac{n}{\sqrt{3}}\right)^n$	$\frac{1}{\sqrt{3}}$
Cylinder (open ends)	$\left(\frac{2n}{3}-B\right)$	$\left(\frac{2n}{3}-B\right)$	$-\frac{1}{2}\left(\frac{2n}{3}-B\right)$	$-\frac{1}{2}\left(\frac{2n}{3}-B\right)$	$\left(\frac{2n}{3}\right)^n$	$\left(\frac{2n}{3}\right)^n$	0	$\frac{2}{3}$
Spherical shell	$\left(\frac{2n}{3}-B\right)$	$\frac{1}{2}\left(\frac{2n}{3}-B\right)$	$\frac{1}{2}\left(\frac{2n}{3}-B\right)$	$-\left(\frac{2n}{3}-B\right)$	$\left(\frac{2n}{3}\right)^n$	$\left(\frac{2n}{3}\right)^n$	$\left(\frac{2n}{3}\right)^n$	$\frac{2}{3}$

For a material with the strain-hardening characteristic $\bar{\sigma}=A(B+\bar{\varepsilon})^n$ the generalised strain at instability $\bar{\varepsilon}=n/\sqrt{3}-B$. The values of the principal stresses and strains are set down in Table II and values of maximum principal strains are compared with the longitudinal strains in uniaxial tension in Fig. 8. It can be seen from the latter diagram that the maximum strains at instability for the case of the cylinder are very much less than the corresponding longitudinal strains in simple tension. Since it is very probable that rupture of the metal of a thin-walled pressure vessel follows very closely after instability, there will be an apparent lack of ductility of the material.

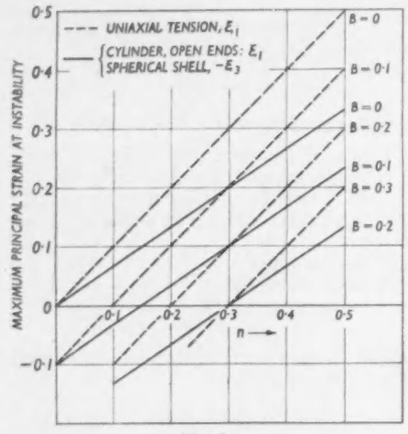

Fig. 8

The internal pressure at instability is easily calculated once the principal stresses and strains are known. Weil (1958) has investigated the bursting pressures of thin-walled vessels for a material having a generalised stress-strain curve $\bar{\sigma}=A\bar{\varepsilon}^n$.

(3) (iii) Thin-Walled Cylinders, with Open Ends, Subjected to Internal Pressure

Davis (1945) has carried out experiments on hollow tubes which approximate to this condition. The axial load was carried by a central rod, leakage of the pressure fluid being prevented by "U"-shaped leather packings. The stress system is then one of pure circumferential tension, $\sigma_1=pr/t$ and the cylinder is free to contract in the axial direction.

At instability $dp=0$ and

$$\frac{d\sigma_1}{\sigma_1}=\frac{dr}{r}-\frac{dt}{t}=d\varepsilon_1-d\varepsilon_3.$$

From equations (11) and (13), when $x=0$,

$$\bar{\sigma}=\sigma_1$$

$$d\bar{\varepsilon}=d\varepsilon_1=-2d\varepsilon_2=-2d\varepsilon_3.$$

At instability, from equation (15),

$$d\bar{\sigma}=d\sigma_1=\sigma_1\,.\,(d\varepsilon_1-d\varepsilon_3)$$

or in terms of generalised stress and strain,

$$\frac{d\bar{\sigma}}{d\bar{\varepsilon}}=\frac{3}{2}\,.\,\bar{\sigma}$$

where the critical sub-tangent $z=2/3$. For the strain-hardening characteristic $\bar{\sigma}=A(B+\bar{\varepsilon})^n$ the generalised strain at instability $\bar{\varepsilon}=2n/3-B$ and the maximum principal strain is $\varepsilon_1=\bar{\varepsilon}$.

(3) (iv) Spherical Shell

For a spherical shell under internal pressure, $\sigma_1=\sigma_2=pr/2t$; the stress ratio $x=1$ and the strain increment $d\varepsilon_1=d\varepsilon_2=-d\varepsilon_3/2$.

The instability condition is $dp=0$ and

$$\frac{d\sigma_1}{\sigma_1}=\frac{dr}{r}-\frac{dt}{t}=d\varepsilon_1-d\varepsilon_3.$$

From equations (11) and (13), for $x=1$,

$$\bar{\sigma}=\sigma_1$$

$$d\bar{\varepsilon}=2d\varepsilon_1=2d\varepsilon_2=-d\varepsilon_3.$$

At instability, therefore :

$$\frac{d\bar{\sigma}}{d\bar{\varepsilon}}=\frac{3}{2}\,.\,\bar{\sigma}$$

and the value of the sub-tangent $z=2/3$. Therefore, the maximum principal strain at instability is numerically the same as the instability strain for the previous case. (See the summary of results in Table II.) The maximum principal strains at instability are greater than for the case of the thin-walled cylinder with closed ends but less than for uniaxial tension, Fig. 11.

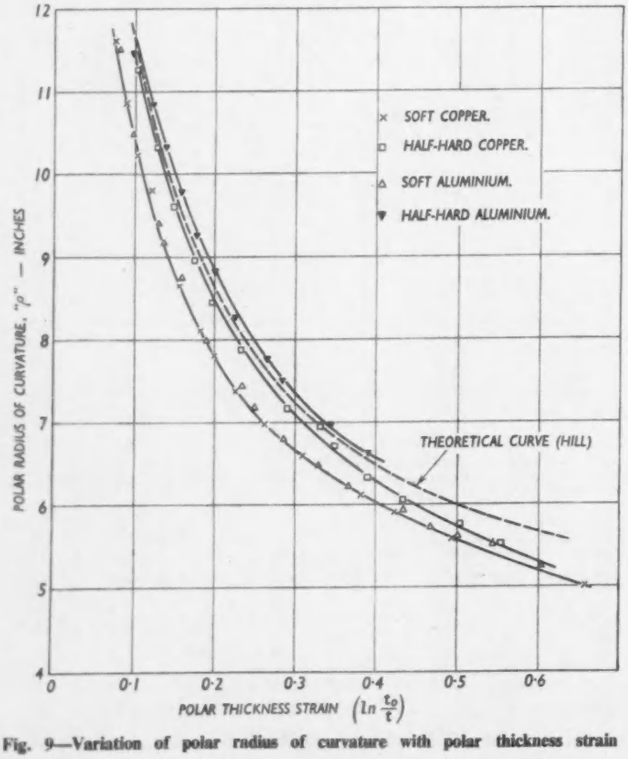

Fig. 9—Variation of polar radius of curvature with polar thickness strain

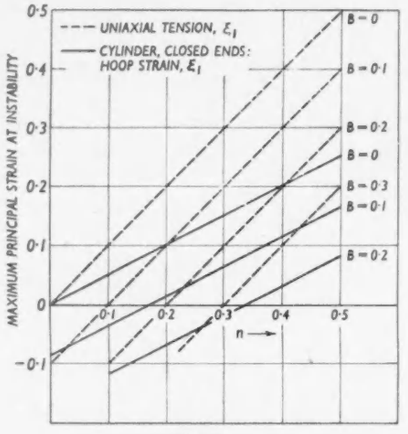

Fig. 11

(4) Circular Membrane

In the processes considered previously, the stress distribution was uniform up to instability. If now a circular sheet of metal is clamped at its periphery and subjected on one side to fluid pressure, the shape of the deforming metal is approximately spherical, except in the region near to the clamped edge, but its divergence from a true sphere is reflected in a changing stress ratio except near to the crown or pole, where, for an isotropic material, $x=1$ throughout. Fig. 12 shows how the stress ratio varies across a membrane of killed steel of 5in radius. The values of stress ratio were derived from strain measurements across the dome, assuming the Lévy-Mises relationship between stress and strain rate. It is seen that, for most of the straining, the dome is spherical within a radius of 2in from the pole and gradually this region extends outwards as the height increases.

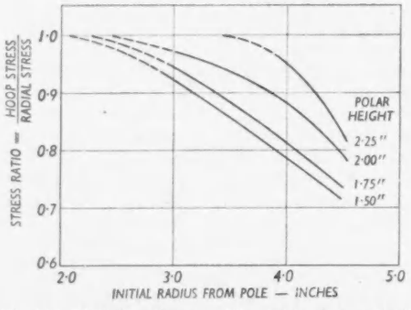

Fig. 12—Variation of stress ratio. Bulge test : killed steel

It is known from experiment that with an

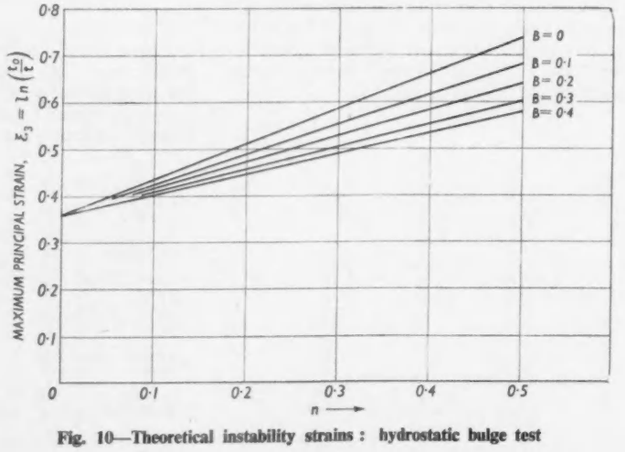

Fig. 10—Theoretical instability strains : hydrostatic bulge test

annealed metal a maximum occurs in the pressure and that fracture follows under decreasing pressure in the region of the pole. The relation between pressure and polar curvature, ρ, is $p=2\sigma_1 t/\rho$ where $\sigma_1=\sigma_2$, the surface stresses at the pole, and t is the current sheet thickness. The normal stress σ_3 is negligible.

At instability $dp=0$ and

$$\frac{d\sigma_1}{\sigma_1}=\frac{d\rho}{\rho}-\frac{dt}{t}$$

or

$$\frac{1}{\sigma_1}\cdot\frac{d\sigma_1}{d\varepsilon_3}=1+\frac{1}{\rho}\frac{d\rho}{d\varepsilon_3} \quad . \quad . \quad . \quad (17)$$

where the through thickness strain ε_3 is defined as the positive quantity $ln(t_0/t)$, t_0 being the initial thickness of the sheet.

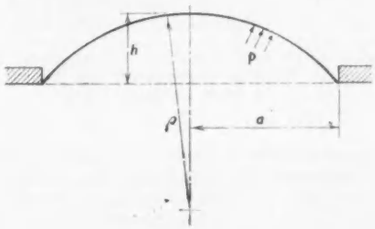

Fig. 13

Hill (1950*b*) obtained a relation between stress and strain at instability by assuming that the particles in the membrane describe circular paths which are orthogonal to the momentary profile. On this assumption,

$$\varepsilon_3=2ln\left(1+\frac{h^2}{a^2}\right);\ \frac{\rho}{a}=\left(1+\frac{h^2}{a^2}\right)\Big/\frac{2h}{a} \quad . \quad (18)$$

where h is the polar height and a is the die radius or initial radius of the blank, Fig. 13. Relation (18) is independent of the properties of the metal and it is a better approximation for the more work-hardened materials, Fig. 9.

From equations (17) and (18), the point of instability occurs when

$$\frac{1}{\sigma_1}\frac{d\sigma_1}{d\varepsilon_3}=\frac{3}{2}-\frac{\rho}{2h}.$$

On expanding in powers of ε_3, this reduces to

$$\frac{1}{\sigma_1}\frac{d\sigma_1}{d\varepsilon_3}\simeq\frac{11}{8}-\frac{1}{2\varepsilon_3}.$$

If the stress-strain curve is fitted by the relation $\bar{\sigma}=A(B+\bar{\varepsilon})^n$ the polar thickness strain at maximum pressure is given by the quadratic equation

$$11\varepsilon_3^2+\varepsilon_3(11B-8n-4)-4B=0.$$

For a fully annealed material B is zero and

$$\varepsilon_3=\frac{4}{11}(2n+1) \quad \text{Hill (1950}b\text{)}$$

The most striking feature about the hydrostatic bulging of a circular metal membrane is that no matter how heavily work-hardened the material is initially, the strain at fracture is always greater than 4/11. This fact makes the " bulge test " a very suitable method of obtaining stress-strain characteristics in tension. The variation of instability strain with B and n is shown in Fig. 10.

Theoretical values of thickness ratio at instability obtained from Hill's solution are compared in Table I with experimental values (Mellor, 1956) for a wide range of materials. Soft brass, half-hard brass and half-hard aluminium fractured under almost constant pressure and it can be assumed, when comparing theoretical and experimental values, that instability and fracture occurred simultaneously. It can be seen that the theoretical values give a good prediction of the instability strains.

The case of hydrostatic bulging is much simplified by the fact that there is no friction acting between the pressure medium and the blank. In stretch-forming with a solid punch, the amount and locality of straining is very dependent on the degree of lubrication between punch and material. The deep-drawing of a circular blank is even more complex, for though instability usually occurs over the punch-head, it is affected by friction and the pull-back forces due to radial drawing and bending over the die.

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Quick Starting of 34MW Turbo-Alternator at Stepney

By F. E. A. REA, A.M.I.Mech.E., M.Inst.F., P. R. CAISTER, A.M.I.E.E., A.M.Inst.F., and S. W. T. BROCK, M.Inst.F.

Quick starting of turbo-alternators is being developed at a number of power stations in Great Britain. Here we describe the procedure worked out at Stepney power station, based on experiments in 1958 *on a* 34*MW set that was installed there in* 1940. *As a result, routine running-up times from " cold " were reduced by* 66 *per cent (to thirty to forty-five minutes) and* 30*MW loading was achieved within one hour of synchronising.*

IT is only in recent years that the importance of the quick starting of turbo-alternators of appreciable size has come into the foreground of technical interest.

The basic problem is to get generating plant, which was originally designed for base-load operation, up to full load as quickly as possible, especially after an over-night or week-end shut down.

At Stepney, the problem has been accentuated by the fact that the highest merit machine is on the borderline between " two-shift " and " peak-load " operation. Even during a cold spell, the decision of Thames North System Control whether or not to use or shut down this set depends on a number of factors. Any of these may change in value from day to day.

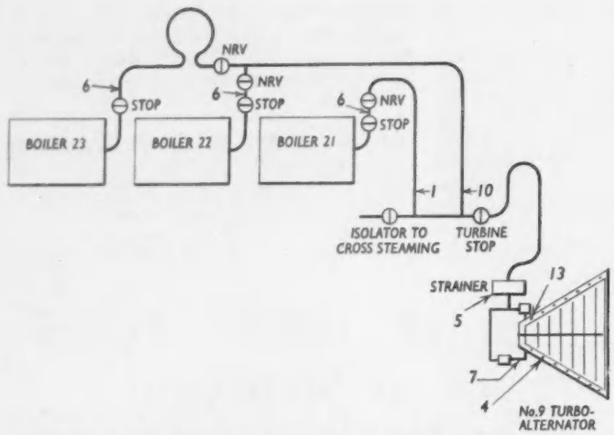
The operational staff can never be sure of the probable duration of any run nor of any shut-down period. Runs on load vary from one hour to sixteen hours. Periods off-load can and do vary from two hours to three weeks, dependent upon the time of the year, the nature of the weather and external plant or feeder limitations.

The experiments have been carried out on a 34MW Fraser and Chalmers turbine coupled to a G.E.C. alternator. It was designed for a steam pressure of 350 lb per square inch gauge and a total temperature of 850 deg. Fah. at the stop valve. The m.c.r. (maximum continuous rating) of this set has recently been raised from 30MW to 34MW and it is frequently run at this loading for extended periods during the winter months, at which time the river water temperature is favourable. The prime mover is a two-cylinder multi-stage impulse machine with twenty-three stages in the high pressure cylinder, and a double flow six-stage low pressure cylinder. Steam enters the h.p. cylinder from two steam chests, one on each side of the cylinder casing. It then flows from the centre of the machine, through the high-pressure blading towards the outboard end pedestal bearing assembly. After leaving the h.p. cylinder the steam passes through twin overhead pipes to the low-pressure cylinder. The rotors are positioned by a pair of Michell thrust bearings, one on each side of the claw-type flexible coupling which is housed in the centre bearing assembly. A transverse key between the bedplate and the l.p. cylinder casing and in line with this coupling provides a fixed anchorage. Both rotors and cylinders are free to expand outwards from this point. A clock gauge fixed to a bracket on the outboard end bearing pedestal measures the differential expansion. The operating plunger of this gauge contacts an expansion indicating pintle device fitted to the end of the shaft by the makers. The change of differential expansion at any one stage inside the h.p. cylinder is, of course, a fraction of that indicated on the clock gauge.

The blading clearances on this machine are comparatively fine. The minimum in the downstream direction of the steam flow is 0·170in at the blade tips of the No. 5 wheel, which is next to the overload steam belt. The smallest clearance in the upstream direction is 0·045in at the No. 3 wheel. Steam is supplied to this turbine from a battery of three Stirling chain grate boilers, the whole operating on a semi-unit principle. These are rated at 150,000 lb per hour m.c.r. and normally one of them acts as a stand-by to the other two boilers. A non-contact type desuperheater controls the temperature of the steam to the turbine. It is integral between the primary and secondary superheaters and is operated by thermostatic control of two butterfly valves. One valve is in parallel and one in series with the desuperheater steam space. Because of site limitations, the chain grate stokers are 1ft shorter than usual and have short " Detrick " type ignition arches. Accordingly, the heat release per square foot of grate area is unusually high for this kind of boiler when steaming at m.c.r. When coal was freely available on a selective basis at economic prices such an abnormality was acceptable. Nowadays it results in difficulties in maintaining stable ignition at high grate speeds if the coal is at all wet. This restricts the rate of pick-up of steam output after an extended banking period.

It should be mentioned that the steam has to flow through approximately 15 tons of piping to reach the turbine from the remotest boiler. This feature has been found very useful in holding down the steam temperature during very cold starts. A diagrammatic layout is shown in Fig. 1.

This boiler-turbine combination was installed in 1940. At that time no instrumentation of a type suitable for quick-start experiments was considered necessary. Running-up and loading after an over-night shut



The figures indicate the position of thermocouples or thermometers as referred to in the text

Fig. 1—Schematic diagram of pipework from Stirling boilers (Nos. 21, 22 and 23) to No. 9 turbo-alternator at Stepney power station

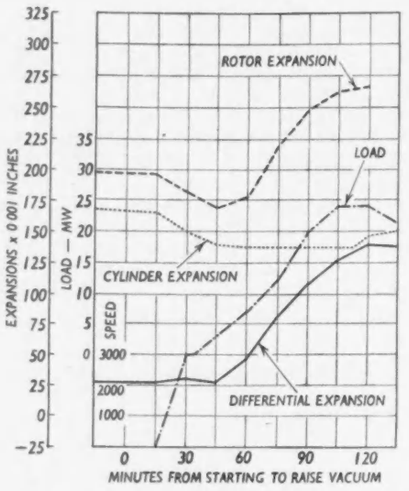


Fig. 2—Quick starting of No. 9 turbo-alternator on August 26, 1958, after nineteen hours' shut down. Note cylinder shrinkage

down was done strictly in accordance with the manufacturer's specifications, which were as follows :

Run-up : Overall time from rolling to synchronous speed, sixty-five minutes.

Synchronise : Three minutes.

Loading: From 0MW to 20MW at a rate of 2MW every five minutes ; from 20MW to 30MW at a rate of 3MW every five minutes.

Total elapsed time from " start-up " : 133 minutes, plus twenty minutes to raise vacuum equals 153 minutes.

After a week-end shut down, the machine was regarded as " cold." Loading was then carried out strictly according to the indications of the differential clock gauge. The tendency to wait for a reduction in differential expansion before proceeding to add more load led to slow and protracted loading times. As much as four hours was taken to reach m.c.r.

Early in 1958 it was decided that, in the light of results being achieved elsewhere, the methods of starting up the 34MW Fraser and Chalmers set should be reviewed and, if practicable, revised.

A further clock gauge was fitted to indicate the movement of the h.p. cylinder outboard pedestal block relative to the bedplate. A capillary type of dial thermometer was also installed to check the temperature of the steam entering the cylinder.

The first experiments were aimed at cutting down the time required to raise the vacuum and run up the turbine. It was found that drastically reduced times were possible with benefit to the smooth running of the set. Run-up times were eventually standardised at :

Less than six hours off load, ten minutes.

More than six but less than twenty-four hours off load, fifteen to twenty minutes.

Over twenty-four hours off load, thirty to forty-five minutes.

These three groups were designated " hot," " intermediate " and " cold " starts, respectively.

As the summer approached, opportunities for " hot " starts disappeared. " Cold " or " intermediate " starts became the order of the day, the former on Monday mornings and the latter mid-week. It must be emphasised that, at this stage, no " out of merit " running nor any other special privileges were arranged with System Control. Steps were taken about the middle of April, 1958, to accelerate slightly the rate of loading within the limitations of the available instruments. The work was slow and empirical until the arrival of a temperature recorder.

The behaviour of the h.p. cylinder under the old starting conditions had become clearer since the second clock gauge was fitted. The indications were that severe contraction of the cylinder had been taking place during the running-up period and during the early stages of loading-up. This had not produced much change in differential expansion while running-up because the rotor tended to shrink as well (see Fig. 2).

Steps were taken to obviate cylinder shrinkage by means of heavy drainage on the boilers during pressure raising and by starting the turbine at reduced vacuum. Thus, a larger volume of hotter steam was admitted to the inlet belt of the h.p. cylinder. Considerable progress had been made along these lines until mid-June, when the set was shut down for c.w. system repairs. Towards the end of this repair period, in early July, 1958, a Divisional temperature recorder became available. No thermometer pockets existed in the steam piping to the turbine, neither could they be fitted because of the danger of swarf entering the main steam pipes which have welded joints.

Thermocouples were fitted to take skin temperatures of the steam pipes and of the h.p. cylinder metal at the inlet end, (1), (10) and (4) in Fig. 1. Also, to one of the horizontal joint bolts at (13) and to the inlet belt steam space at (7). The existing Cambridge distance thermometers were used to indicate the steam temperature at (5) and (6).

On July 16, 1958, the first instrumented run-up took place. By arrangement with System Control, it was of the previously " normal " timing for a cold start with a target loading of 30MW. The only concession to the new knowledge was that the set was started up under reduced steam conditions. This run was laid on to provide a datum line by which to judge the subsequent runs. Results showed that during the run the maximum differential temperature between steam and metal at the inlet belt was 265 deg. Fah. It was in excess of the accepted figure of 200 deg. Fah. for forty-five minutes. The onset of this high differential occurred thirty-five minutes after synchronising, i.e. 100 minutes after commencing to turn the set. At this time the load had only reached 3MW. The rate of rise of the cylinder metal temperature was evenly spread at 10 deg. Fah. per minute and persisted for forty-five minutes, but reached 70 deg. Fah. per five minutes for the steam pipes. This was well in excess of the accepted 10 deg. Fah. per minute. Unfortunately, the differential expansion clock gauge went out of adjustment by accident during the loading period, so that an accurate reading was impossible. The value was, however, estimated to be of the order of 0·150in to 0·155in total differential at the extreme end of the h.p. rotor. It would, of course, have been only a fraction of this figure at the No. 5 wheel. This turbo-generator had been operated under these or still more onerous conditions for nearly eighteen years without any apparent bad effects on the cylinder metal. It therefore appeared to be permissible to proceed with the experiment provided that these recorded values were regarded as maxima. The next opportunity for a cold start occurred on the following Monday morning, July 21, 1958, after a shut down period of eighty-nine hours. This time the run-up was reduced to thirty minutes and the rate of loading slightly accelerated. A load of 20MW was reached after two-and-a-half hours on load against three hours for the previous run. The maximum steam-to-metal temperature differential was 260 deg. Fah. and was in excess of 200 deg. Fah. for only thirty-eight minutes. This was an improvement over the previous run, although the rate of loading for the first half-hour was nearly doubled. The rate of increase of metal temperature of the inlet belt was unaltered at 10 deg. Fah. per minute. The rate for the steam piping had halved at 70 deg. Fah. over ten minutes. It appeared so far that the effect of quicker starting on metal conditions was beneficial provided that steam pressures and temperatures could be kept down.

On Monday, July 28, 1958, the set was again called for, having been off-load for 161 hours. This time the run-up was lengthened to forty-five minutes but pressure was reduced to the minimum under which the air ejectors would operate effectively, i.e. 250 lb per square inch gauge. The superheat controls were manually set hard-over to maximum desuperheating. The rate of loading was considerably increased this time, and 20MW was reached after two hours only. The maximum steam-to-metal differential temperature dropped sharply to 205 deg. Fah. and only remained in excess of 200 deg. Fah. for four minutes. The rate of rise in metal temperature only reached 10 deg. Fah. per minute for ten minutes in the case of the cylinder and 4 deg. Fah. per minute for ten minutes in the case of the pipework. The maximum differential expansion was comparable with the previous runs at 0·155in (Fig. 3).

It was considered that if the steam temperature could be reasonably closely matched to that of the cylinder metal, the steam-to-metal temperature differential would be acceptable. Close control of the rate of rise of steam temperature with load would keep down the differential expansion. Thus, quicker starting should create better thermal conditions for the pipework and the cylinder castings as compared with the previous practice.

With the coming of October, more opportunities for " intermediate " and " hot "

starts came along. The Stepney staff reasoned that what was good with cold starts would be equally good with the hotter starts. Loading rates continued to increase and now some spirit of emulation between shift and shift began to appear.

The technique for cold starting had become an established routine aimed at securing a load of 30MW within one hour of synchronising. Running-up took from thirty to forty-five minutes, according to the initial condition of the h.p. cylinder : this was one-third of the previous time.

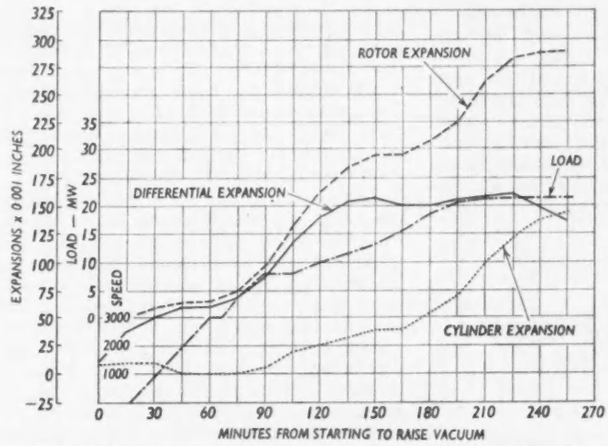


Fig. 3—Quick starting of No. 9 turbo-alternator on July 28, 1958, after 161 hours' shut down

When starting after an over-night shut down, after an off-load time of between twelve and twenty hours, run-up times became fifteen to twenty minutes. Loading time was reduced to thirty and thirty-five minutes for full m.c.r. of 34MW, i.e. forty-five to fifty-five minutes from turning the set. Steam dumping had now to be practised in order to raise the steam temperature at the stop valve to the required value.

With a " hot " start, after a shut down of two to six hours, running-up time was cut to eight to ten minutes. Loading time became fifteen minutes for 30MW and twenty minutes for full m.c.r. It was now found that the residual linear expansion of the h.p. cylinder was a better guide to the required steam temperature at starting-up than an arbitrary scale of temperature derived from rate of cooling and time-off load. This is thought to be due to heat-soak taking place after the machine is shut down. Another factor is that with this turbine there are two stages of throttling between the steam strainer and the inlet belt instead of the more usual single stage. To assist in achieving such high rates of load pick-up with the firing equipment installed, it was found that the third Stirling boiler was a valuable asset. It could be used to spread the burden on the boiler plant and also reduced the pressure drop across the desuperheaters when conditions were set for maximum desuperheating. This third boiler is now regularly used when starting up. It is dropped out as soon as normal conditions can be restored. At first this seemed to be an uneconomical practice that had to be accepted because of the design limitations of the installed plant. Experience has shown that the loss of economy is not serious. There are compensating factors such as reduced loss of combustible over the backs of the grates. This is because of the lower grate speeds permissible, particularly when the arches are comparatively cold. There is also the fact that plant reaches economic steaming rates much earlier than used to be the case. These rates are now maintained over a much greater proportion of the total time on load. With the short periods on load which are now characteristic of small station operation, this is an important point. Much higher running load factors are obtainable than would otherwise be possible.

By the end of October, 1958, the improved economy of the station began to show up in the generating statistics. On several occasions certain shifts had achieved remarkable figures for starts after some twenty hours off load. About this time, too, considerable progress had been made in quicker unloading. This was done in order to conserve as much heat in the cylinder as possible, against the next run. The set was frequently off the bars within fifteen minutes of receipt of instructions to " ease away and shut down." At this time runs were confined to evening peak work and were of the order of two-and-a-half to four hours in duration.

The combined effect of quicker pick-up and quicker unloading was to boost the running load factor to unprecedented heights. On several evenings the load factor reached or exceeded 75 per cent. It will, of course, be appreciated that the achievable load factor depends on the instructions received from System Control as well as on the efforts of the station staff. For instance, if the set is only called upon for half-load with a short, say, fifteen-minute peak up to full load, it is impossible to get a load factor over 50 per cent. For this reason there were only a few occasions when better values were possible. Two examples from the October data are quoted to illustrate what can be achieved if quick starting and unloading techniques are conscientiously applied.

October 28, 1958 : *No.* 9 *Set Called for* 16.30 *Hours*

Commenced to raise vacuum	16.05 hours
Set turning 18in vacuum	16.13 hours
Turbine up to speed	16.28 hours
Synchronised and on load	16.30 hours
Load 30MW	16.49 hours
Total time	44 minutes
" Ease away and shut down "	18.38 hours
Machine off bars and tripped	19.00 hours
Total time	22 minutes
Printometer reading for 19.00 hours...	28.700

On this occasion, with the second set on load from 16.45 hours to 18.40 hours, the running plant load factor was 87 per cent.

October 30, 1958 : *No.* 9 *Set Synchronised at* 16.00 *hours*

Load between 22MW and 30MW from 16.12 hours to 18.20 hours off bars and shut down 18.35 hours.

During the following months, results gradually became consistent as performance improved with practice. Whenever System Control requirements permitted, good figures were returned. For instance, on November 19, the 34MW Fraser and Chalmers set was called for " as soon as possible " at 10.50 hours, after being off-load overnight from the previous evening's peak. The sequence was : called for, 10.50 hours ; on load, 11.15 hours ; 22MW, 11.27 hours. In the evening of the same day the set was on load at 15.45 hours and at 22MW at 15.55 hours, further increments being met instantly on request ; maximum differential expansion 0·110in.

The following day, after twenty-one hours off load, Control's request for 22MW was met eight minutes after synchronising. The maximum differential expansion was 0·115in at a loading of 27MW.

On November 26, after a lunch-time shut down lasting nearly three hours, 30MW was picked up in fifteen minutes. This time the maximum differential expansion was 0·114in.

These low differentials were due to the initial cylinder shrinkage having been prevented by close matching of steam and metal temperature and to the provision of a large volume of steam to keep the cylinder moving forward close behind the rotor expansion. They are the lowest figures ever recorded during the whole of the test period.

The improvement in performance was due in no small measure to the keen interest being taken in the experiments by all the staff concerned. This interest transmitted itself to maintenance personnel. They began asking for the fullest information about what was going on. In all probability the greatest benefit to Stepney arising from these successful experiments was this reawakened interest in the commercial standing of the station. Its consequent boost to morale led to better standards of work all round. Examples of this are given below. The two particular weeks are picked out because the units generated for the week were very close to those of the corresponding week of the previous year.

Improvements in Performance at Stepney Power Station

	Week ending December 12	
	1958	1957
Units generated	1,543,000	1,558,000
Units sent out	1,442,000	1,436,000
Units supplied	1,392,000	1,389,000
Units consumed on works while generating	101,000	122,000
Works units per unit sent out, per cent	7	8·5
Hours generating	55·5	72·5
Average length of run, hours	4½	10¼
Station running load factor (week), per cent	56	37
Make-up water, per cent	12·03	11·16
Overall thermal efficiency, per cent	20·6	20·1
No. of load cycles	12	7

	Week ending January 9	
	1959	1958
Units generated	1,854,000	1,432,000
Units sent out	1,732,000	1,309,000
Units supplied	1,680,000	1,259,000
Units used on works while generating	174,000	173,000
Works units per unit sent out, per cent	7·04	9·4
Hours generating	60·75	69·5
Average length of run, hours	4·25	8·75
Station running load factor (week), per cent	57·06	39·95
Make-up water, per cent	7·198	10·36
Overall thermal efficiency, per cent	22·34	20·99
No. of load cycles	14	8

	Week ending January 30	
	1959	1958
Load cycles	13	7
Average length of run, hours	5·5	11·125
Station running load factor (week), per cent	60·34	38·11
Running load factor, No. 9 machine (week), per cent	76·2	—

The above weekly load factors are especially significant when it is borne in mind that they include week-ends when very few units are generated. The thermal efficiency figures become more significant when it is appreciated that in the winter 1958–59 14 per cent of the units were generated on lower merit

plant as against 5 per cent in the winter 1957–58.

Conclusions

The results of the tests at Stepney demonstrate that even on short runs, provided the machine is given the load by System Control, load factors of the order of 75 per cent can be achieved. This means considerable benefit to station morale as well as station economics, particularly when, as in the case of Stepney, that station is faced with continuous reduction in the length of periods on load coupled with starting-up and shutting-down twice a day.

The operation of the 275kV supergrid will dominate the loadings of the London power stations from 1960 onwards. For economic reasons, some proud base-load stations will have to come down to two-shift or peak load operation. Quick-starting will then become a vital necessity to preserve their economic status and their morale. This is apart from the necessity to meet the requirements of the L.E.B. and neighbouring Area Boards.

Acknowledgments

Our thanks are due to Mr. H. J. Bennett, Regional Director of the London, Eastern and South Eastern Region of the C.E.G.B., for permission to produce this article; to Thames North Control for their unfailing encouragement and co-operation in pursuing our experiments; to the Divisional Test and Efficiency Department for their interest and the loan of their apparatus at a time when they were under pressure to use it elsewhere; also to the technical, maintenance and operating staffs at Stepney for their keen interest and co-operation in carrying out the tests.

Locating Electric Cables Under Water

By E. C. WADLOW, B.Sc., Ph.D.

In several instances lately (see, for instance, The Engineer, *September* 26, 1958) *where electric cables have been laid across rivers, harbours, and even in the open sea, free swimming divers have been employed to check that the desired position and spacing have been obtained correctly. This, of course, is an easy matter provided the depth of water, tides, currents, water temperatures, &c., are such that the diver can operate satisfactorily. In comparison, the problem of ascertaining the location of underwater cables which have been laid for many years is usually less simple. Often no steps were taken during laying to check the actual position of the cables, and over the years they may well have moved or become buried in the material of the river, harbour or sea bed. But here again the free swimming diver has provided a solution to the problem which was previously rather intractable. Where formerly it was usually necessary to operate from boats on the surface, with errors due to movement of the boat, and the intervening depth of water rendering all means of measurement much less sensitive, now it is possible to work directly on the bottom with almost as much ease as on dry land.*

PROBABLY the simplest methods of locating buried cables are those which depend on the detection and measurement of the steady magnetic field external to the cable when it is energised electrically with direct current. These enable the diver to use a simple compass needle as the detecting instrument and the depth of the cable can be calculated directly from first principles. No complications arise from the presence of steel armouring wires round the cables, and no complex electrical or electronic equipment has to be used. However, since underwater cables are rarely laid singly, there is usually a fairly effective cancellation of external magnetic field effects when all cables are energised simultaneously, as occurs in normal power circuits. Thus, to facilitate location by the use of the external magnetic field, it is always desirable to be able to energise one cable at a time, which involves the provision of a return circuit sufficiently remote from the cable under test to avoid any cancellation effects between the magnetic fields caused by the two arms of the circuit.

In circumstances such as those under consideration, however, where the cable system crosses an appreciable width of water, it is not always practicable to arrange a special remote cable for the return circuit. Fortunately, it is often possible, in saline waters at least, to employ the water itself as the return circuit, using electrodes, one on either side of the channel, provided care is taken to place the electrodes of sufficient area far enough from the cable under test.

The general principles on which the methods to be described are based are simple and well known, but it will be useful to consider them briefly in relation to the specific problem of locating cables in plan and depth below a submerged ground surface.

The steady magnetic field due to the passage of a constant direct current in a single isolated cable completely envelopes the cable and at any point distance r cm from the cable carrying I amperes the strength of the magnetic field tangential to the radius is

$$F=\frac{2I}{10r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Suppose, for simplicity, that the cable C (Fig. 1) lies along the meridian assumed perpendicular to the paper. At any point P in the horizontal traverse AB, height d above the cable, the field acts in a direction PQ at right angles to CP for the direction of current flow shown, and has a strength given by equation (1). The horizontal component,

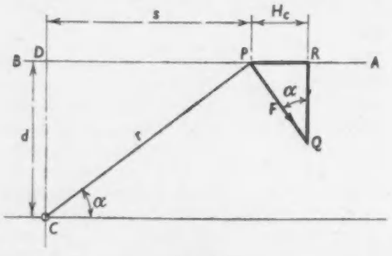


Fig. 1

H_c, equals F sin α, and since sin $\alpha=d/r$ and $r=\sqrt{d^2+s^2}$,

$$H_c=\frac{2 \cdot Id}{10(d^2+s^2)} \quad . \quad . \quad . \quad . \quad (2)$$

If a compass needle is placed at P it will align itself with the resultant, H_r, of H_c and the horizontal component, H_o, of the earth's magnetic field. The angle of deviation, ω, is given by

$$\omega=\tan^{-1}\frac{H_c}{H_o} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This is clearly a maximum when the needle is at point D, directly above the cable, and thus the method of traversing a compass needle across the cable provides a very convenient means of locating the cable in plan. When the point D has been found, the depth of the cable can be readily calculated from equation (1), since here $r=d$.

These simple relationships only hold when the cable lies exactly along the meridian. For other cable orientations, ω is still the angle between the magnetic meridian and the resultant, H_r, of H_c and H_o, but the latter are no longer at right angles and equation (3) no longer holds—the more general methods of resolving the forces and determining the angles must be adopted. If the cable orientation and direction of current flow are such that the angle between H_o and H_c is decreased, then H_r increases and ω decreases. Conversely, if conditions are such that the angle between H_o and H_c has increased, then H_r decreases and ω increases. In both cases the sensitivity of the method decreases as the cable orientation departs from the meridian. When it is at right angles to the meridian, $H_r=H_o \pm H_c$, as the case may be, $\omega=0$ and the method cannot be used with a normal compass needle.

When the cable orientation is more nearly at right angles to the meridian it may be best to employ an alternative method based on

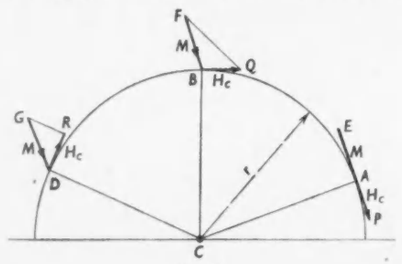


Fig. 2

the use of a dip needle. Suppose, Fig. 2, that the axis of the cable is exactly at right angles to the meridian. When the cable is energised with direct current the magnetic field due to the current at radius r is everywhere at right angles to the radius, as shown by AP, BQ and DR for points A, B and D. The total intensity of the earth's magnetic field at these points is shown by EA, FB and GD, all equal and inclined to the horizontal at the angle of dip θ, appropriate to the geographical location of the cable. A dip needle capable of turning only in the plane of the meridian will take up a declination in line with the resultant of cable field and earth's total intensity field, at all points.

Suppose now, Fig. 3, that the cable C is

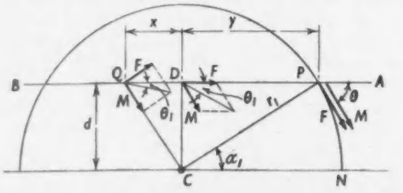


Fig. 3

buried at a depth d below the surface AB and that the dip needle is traversed along this surface and not around the circle, as in Fig. 2; r is the distance from C to any point on the traverse; α is the corresponding angle to the horizontal.

Starting the traverse from A, a point P will first be found where, for the direction of current flow assumed, the field due to the steady direct current in the cable will have the same direction as the normal declination θ of the earth's field. Continuing along the traverse towards B, the strength of the cable

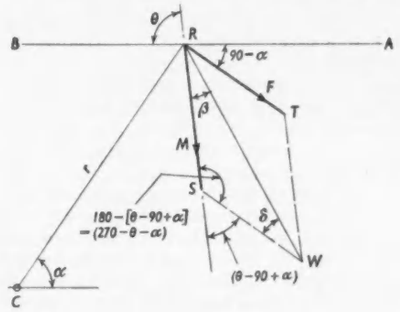


Fig. 4

field will increase, since r decreases, and its inclination to the horizontal will decrease. At D, immediately above C, the cable field will be horizontal and a maximum. Beyond D it will be directed upwards at increasingly steep angles, but its magnitude will fall off beyond D, since r is now increasing again. The observed declination θ_1 at all points along the traverse will be that of the resultant of the cable field F and the total intensity M of the earth's field. There will be some point Q in AB, where θ_1 is a minimum. If angle PCQ is assumed to be 90 deg., $QD=x$, $PD=y$, $CP=r$, angle $PCN=\alpha_1$, then

$$d=(x+y)\sin\alpha_1\cos\alpha_1 \quad . \quad . \quad . \quad (4)$$

$$\frac{x}{x+y}=\sin^2\alpha_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

But since, at P,

$$\alpha_1=90-\theta$$

$$d=(x+y)\sin\theta\cos\theta \quad . \quad . \quad . \quad (6)$$

$$\frac{x}{x+y}=\cos^2\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

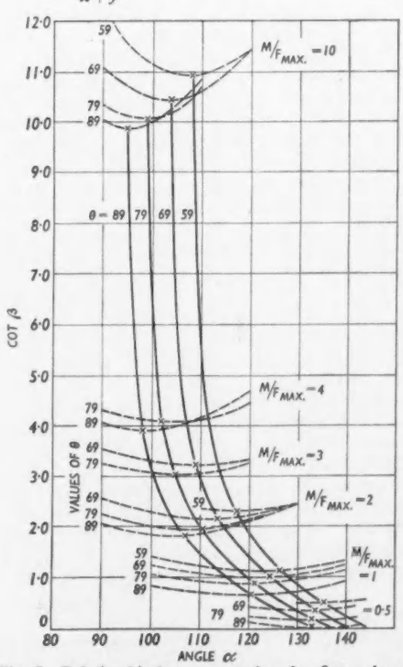


Fig. 5—Relationship between cot β and α for various values of θ and M/F_{max}

Thus, if the angle of dip, θ, is known, and if the distance PQ is observed by making a traverse with a dip needle, both the location of the cable in plan, and its depth, can be determined.

But angle PCQ is not a right angle in all circumstances. Its value depends on the current I in the cable, on the depth, d, and on the angle of dip, θ. It is therefore of interest to consider in more detail the circumstances in which PCQ is a right angle.

The conditions at any point R in the traverse AB are shown in Fig. 4. Here RS is the total intensity, M, of the earth's magnetic field at a dip angle θ to the horizontal. RT is the magnetic field, F, due to the current in the cable (assumed still to be at right angles to the meridian). RW is the resultant inclined at an angle β to the direction of the total intensity, M, of the earth's field.

Then,

$$\frac{\sin\delta}{\sin\beta}=\frac{M}{F} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

But

$$\sin\delta=\sin(\theta+\alpha-90-\beta)$$
$$=\sin(\mu-\beta) \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where

$$\mu=(\theta+\alpha-90)$$

Therefore

$$\frac{\sin\mu\cos\beta-\cos\mu\sin\beta}{\sin\beta}=\frac{M}{F} \quad . \quad . \quad (10)$$

from which

$$\cot\beta=\frac{\frac{M}{F}+\cos\mu}{\sin\mu} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

But, from Fig. 1

$$r=\frac{d}{\sin\alpha}$$

Therefore

$$F=\frac{2I\sin\alpha}{10d}=F_{max}\sin\alpha \quad . \quad . \quad (12)$$

where

$$F_{max}=\frac{2I}{10d}$$

Therefore

$$\cot\beta=\frac{\frac{M}{F_{max}\sin\alpha}+\cos(\theta+\alpha-90)}{\sin(\theta+\alpha-90)} \quad . \quad . \quad (13)$$

Fig. 5 shows the relationship between cot β and α for a number of different values of θ and M/F_{max}. But the angle PCQ (Fig. 3) is equal to $(\alpha-\alpha_1)=(\alpha-90+\theta)=y$ say, where α=angle QCN. The results of Fig. 5 may be replotted on a base of y as shown in Fig. 6. Since, as will be seen from Fig. 5, M/F_{max} is approximately equal to cot β for all values of cot β greater than 1·0, values of M/F_{max} and θ for which the angle y equals, or nearly equals, 90 deg. can be read off from Fig. 6. Then, assuming a value of d, the value of I necessary for y to be approximately 90 deg. can be determined. Should the value of d be found on the first experimental run to be radically different from the value assumed, it may be necessary to recalculate I and repeat the run. But as y is very insensitive to changes in M/F_{max} it is unlikely that a second approximation will be necessary. And since cos $(\theta+\alpha-90)$ may be made small in relation to M/F_{max}, and the sine function is relatively insensitive to changes in angle when the angle is not far removed from 90 deg., the calculated values for position and depth of cable will not be greatly in error even if y varies from 90 deg. by as much as ±10 deg.

Figs. 5 and 6 also show the effect of varying θ between 59 deg. and 89 deg. θ may vary due to geographical location. Its value is also dependent on the angle which the measurement plane makes with the meridian. As the cable direction approaches more nearly to the meridian so the apparent angle of dip of the earth's field in the plane of measurement increases, to become 90 deg. when the cable lies in the meridian and the traverse is at right angles to it. It will be seen from Fig. 6 that even in these circumstances it is possible to make y nearly equal to 90 deg. The difficulty then results, however, from the fact that M/F_{max} is necessarily large and α_1 very small. Thus the cable field has to be weak, while the distance, $r=RC$ in Fig. 4, is necessarily very great. There is thus a lack of sensitivity in the determination of the point P (Fig. 3), where the direction of the cable field is that of the total intensity of the earth's field.

Thus there are two simple methods available for determining the plan location and depth of a d.c. energised cable under water. The first, using a compass needle, is most applicable when the cable lies more or less

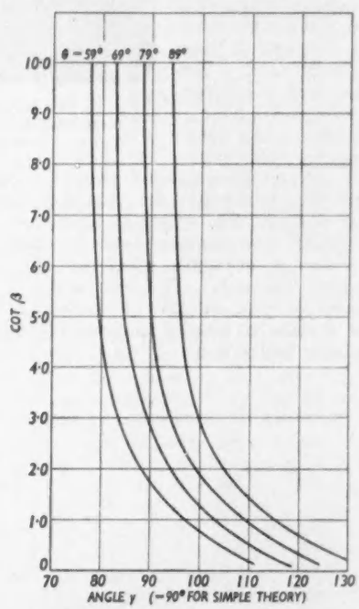


Fig. 6—Relationship between cot β and y for various values of θ and M/F_{max}

in the direction of the magnetic meridian, and the second, using a dip needle, is most applicable when the cable lies more or less at right angles to the meridian. Over a fair range of cable orientations it is possible to employ both methods, when one may be used as a check on the other.

The range of application of either method can also be increased by simple modifications. With the first (compass needle) method, the sensitivity as the cable approaches an East-West direction can be restored by introducing an artificial constant magnetic field in the neighbourhood of the compass needle, so that it no longer points along the meridian in the absence of the field due to the cable current. With the second (dip needle) method, the sensitivity for angles of θ→90 can be restored by weighting the S pole of the dip needle which gives the same effect as a reduction in the vertical component of the earth's magnetic field and hence in the value of θ.

Compass Equipment

Fig. 7 shows a compass specially designed for use under water. External controls are provided (*a*) to lock the compass needle in

any position which it has taken up and (*b*) to rotate the whole compass through 90 deg. inside the instrument body so that the needle can swing in either a horizontal or a vertical plane, respectively, as desired. The needle locking device is particularly valuable when the instrument is being used to make dip angle measurements. In this position the scale is difficult to read when the instrument is on the river or sea bed. But it is easy to lock the needle once it has assumed the angle of the resultant, and then rotate the whole compass through 90 deg. when the scale now horizontal, can be easily read. The whole casing is made of transparent plastic, but for use under water a battery fed lamp with an externally operated switch is provided to illuminate the compass scale when desired. The magnetic field due to the battery and the lamp leads is arranged to have a negligible effect on the instrument readings. The instrument as a whole is just negatively buoyant, so that it can be handled conveniently by a swimmer under water.

Fig. 7—This compass is specially designed for use under water. Observe that the compass can be rotated through 90 deg. The needle can also be locked in position. Buoyancy is slightly negative

Practical Applications

In practical problems of cable location under water the positions where the cables enter and leave the water are usually known accurately, and the first action is to lay a jackstay as tight and straight as possible along the bottom between these two known points. If necessary the jackstay can be buoyed at intervals and its position checked against shore marks if there are periods of slack water when the buoys can be maintained immediately over the jackstay. Since the jackstay is the diver's main reference under water it is marked along its length at convenient intervals, and it should be secured firmly to the bottom either by sinkers or by pegs driven into the bottom.

Transverse lines, a hundred feet or so in length, and also marked at convenient intervals, are next set out at selected intervals along the jackstay and at right angles to it. They are similarly pulled taut and secured to the bottom.

The directions of lay of both jackstay and transverse lines are then determined by compass, under water, with no current in the main cables for which search is being made. If lines are used which are affected by water care must be taken to allow for any contraction in length which occurs when the lines become wetted.

The current in the main cable is now switched on and the diver makes his runs along the traverses, observing the deviation or dip angles, as the case may be. The observations may either be recorded directly by the diver, or transmitted to an assistant in a boat above.

The practical procedure, as described, sounds very simple, but actually calls for considerable skill and experience if it is to be carried out with expedition and accuracy. The observations may be analysed by the methods outlined earlier in this article.

Acknowledgment

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Use of Resistance Strain Gauges

By K. G. MANTLE, B.Sc. (Hons.), A.M.I.Mech.E., A.M.I.Prod.E.
and E. PROCTER, A.M.I.Mech.E.

Whilst a great deal of literature is available on the theory and application of electrical resistance strain gauges, there is a shortage of information describing the techniques of actual gauge use, particularly with reference to practical details such as gauge application and wiring. In 1956 a decision was made to form an experimental stress analysis section in the Group Laboratory of John Thompson, Ltd., and since there was no personnel available with practical knowledge of the use of resistance strain gauges, the staff of the section had to learn by experience. It is considered that an account of the details of the techniques now employed may be of interest, together with a mention of some of the mistakes which have been made during the evolution of these techniques. When work was commenced a great deal of useful advice was obtained from the British Welding Research Association, and this formed the basis of the system described. Their methods are fully covered in an article by P. H. R. Lane, "The Engineer," December 6, 1957.

AFTER a series of tests on commercially available gauges, a particular type and make of gauge was chosen, and is now used for the majority of installations. The factors which influenced the choice of this gauge were quality of manufacture, in particular the alignment of gauge grids, mechanical strength and the ease of application and lead attachment. For most purposes a gauge with a ½in grid length has been found to be quite satisfactory, although in some cases, where the stress gradient is high, ¼in grid lengths are used. Since the surface stress field in some structures is biaxial, stresses can only be determined by the measurement of strain in at least two directions. If the directions of the principal stresses are known, a right-angled pair of gauges at each measuring station is sufficient and these are generally applied as a commercially supplied "crossed-pair." In cases where planes of principal stress are not known, rosette gauges are used. In both types the gauge grids lie one on top of the other and thus effectively measure at the same point. This cross-over of grids has not been found, on good quality gauges at least, to materially affect the gauge factors.

The first essential for accurate strain gauge work is to achieve a satisfactory bond between the strain gauge and the surface to which it is to be attached. This surface should be of a smooth contour and free from any local defects. Various types of grinders are used for preparation, depending upon surface condition, and if there are any bad defects these are weld filled before grinding. The object is to achieve a surface which is smooth and clean but definitely not polished, since this does not promote adhesion. It is usual to hand finish with "0" grade emery. It is considered that the ideal surface finish can be achieved by sand blasting, using 80–100 mesh grit, and a suitable portable apparatus is available for this preparation. This method also speeds general surface preparations.

The standard adhesive now used is Araldite strain gauge cement, this having proved simple and satisfactory with any type of strain gauge, and much more tolerant of surface preparation than other types of adhesive. It should be noted that in making up the small amounts of cement necessary for strain gauging, considerable care is essential when measuring quantities for mixing. Cellulose adhesives were originally used, but the number of gauges rejected due to faulty adhesion was excessive, and consequently the use of this type of adhesive was discontinued.

Immediately prior to application of the gauge, the ground surface is finally roughened with emery, being rubbed in such a way that it is abraded in all directions, and then very carefully cleaned with trichlorethylene or carbon tetrachloride. A thin film of Araldite strain gauge cement is then laid on by spatula, the gauge applied in its required position and gently smoothed out from the centre to avoid air bubbles. The gauge is then lightly clamped during the curing period (see Fig. 1). This is effected,

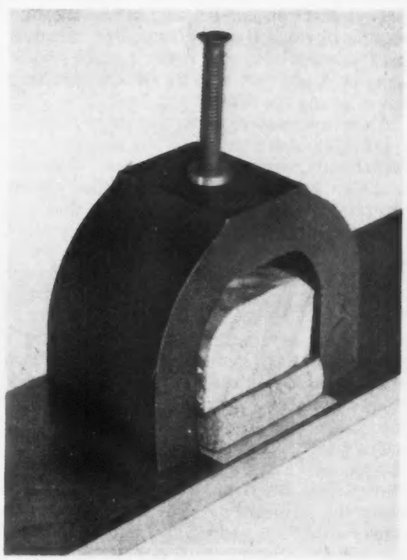


Fig. 1—Clamping of gauge on ferrous structures

on ferrous structures, by bridging the gauge with a simple horse-shoe magnet fitted with a screwed bush, through which the clamping screw runs. A sheet of polythene is laid over the gauge and a piece of foam rubber on top of this, the polythene preventing adhesion between the gauge and foam rubber. A wooden block, roughly shaped to the contour of the surface where the gauge is applied, is laid on top of the rubber, and the whole is clamped from the magnet. Care is taken not to use excessive clamping pressure, about 2lb to 3lb per square inch. Curing of the adhesive, whilst quite satisfactory under ambient temperature conditions, is assisted by gentle heat, especially in damp atmospheres. Infra-red lamps are generally used for this purpose.

On completion of gauging, three tests are applied to each gauge. Two of these, the test for continuity and gauge resistance, and the test for earth resistance, are normal and need not be described, but the third, the push test, is not so well known. This is a test of the adhesion of the gauge, and any imperfections such as uncured adhesive or air bubbles under the backing paper are exposed by it. The gauge to be tested is connected to the strain indicator, which is then balanced to zero. Pressure is now applied, both normal to and along the surface of the gauge, a rubber on the end of a pencil being used, and this causes a deflection on the measuring instrument. For a properly attached gauge this deflection is small, corresponding to a few micro-inches per inch, and when the pushing force is removed, the measuring instrument pointer returns to zero. This push test is very stringent but gauges which do not pass it are always rejected.

All gauges are protected immediately they have passed their acceptance tests, the method of protection depending upon the service conditions. For gauges subjected to a normal indoor atmosphere a coating of wax is satisfactory, but for outdoor use it is usual to cover the gauge with either Araldite strain gauge cement or Araldite casting resin D. For gauges on the inside surface of vessels subjected to hydraulic pressure, a rather more elaborate protection is required. The method used is generally as reported by Lane* in 1957 and need not be described in detail. Briefly, the method consists of covering the gauged area with a bitumastic compound which is melted and poured on. The surface on to which the compound is poured must be absolutely free from oxidation, grease or dust, otherwise there is a likelihood of breakdown in waterproofing. Since the time lag between grinding and waterproofing may be considerable, the prepared metal surface may become sufficiently oxidised to give poor adhesion. This trouble has been experienced, although the surface appeared to be satisfactory. To prevent this the area surrounding the gauges is painted with bitumastic paint as soon as the clamping magnets are removed. This protects the surface and provides a bond for the waterproofing compound when this is poured.

Initially gauge leads were single p.v.c. insulated 7/·0076in tinned copper wire, but twelve-core cable is now used. This change to multi-core cable was made originally since it was considered that the sealing of cables passing from the inside of a pressure vessel could be more readily effected with this cable. Sealing is carried out as shown in Fig. 2 using a rubber-packed sealing gland

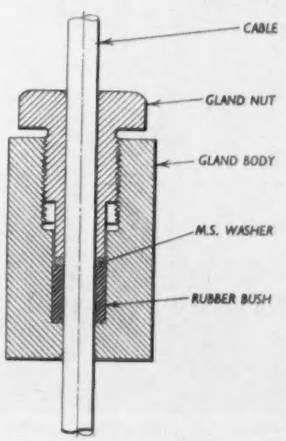


Fig. 2—Cable sealing gland

and this has proved quite satisfactory, having been used repeatedly for a maximum pressure of 3000 lb per square inch where it showed no signs of leakage. Subsequently the use of multi-core cable proved to have several other advantages, in that it is neater,

* "Notes on the Use of Resistance Strain Gauges," by P.H.R. Lane, THE ENGINEER, Vol. 204, December 6, 1957, page 812.

less susceptible to damage, and gauge identification is much simpler. Each gauge tag is soldered to a separate core, thus six gauges are connected per cable. The cable is clipped local to the block of gauges being wired,

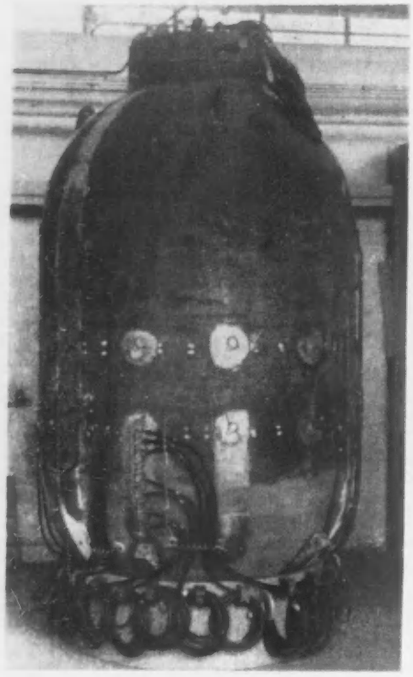


Fig. 3—Set-up of gauges on pressure vessel

using a polythene strap screwed to a light bridge piece which is tack welded to the structure (see Figs. 3 and 4). Individual gauge leads are temporarily fixed using adhesive tape and finally secured with spots

Fig. 4—Cable clipped local to block of gauges

of strain gauge cement. The connection between lead and gauge tag is covered with an insulating sleeve to prevent any possibility of short circuits. When waterproofing internal gauges it is essential to lift the cable slightly so that the compound runs all round it, and also to ensure that there is sufficient depth to completely bury all the leads to the strain gauges and also the open end of the outer cover where the various cores part to the gauges. In addition all cables entering waterproofing compound should be degreased before pouring.

The measuring instrument generally used for all static strain measurement is a single-channel strain indicator by the Baldwin Lima Hamilton Corporation. This has proved satisfactory in every respect, being portable, extremely robust and simple to use. The instrument is calibrated to read directly in micro strain and the normal method of operation is to obtain a reading for each strain gauge with no applied load, then to repeat the procedure under load, the strains due to the load being the difference between these two readings.

The instrument was adapted for multi-channel work by the use of switch boxes, each to take fifty active and fifty compensating gauges. Four-way switching with silver-plated wafer switches was adopted, each gauge arm being switched individually. The alternative to this would have been to switch in the galvanometer arm of the bridge. The objection to this second circuit was that if the insulation resistance broke down on only one gauge, then all gauges on that circuit would be affected. It soon became obvious that the switching arrangement adopted was not really suitable, there being evidence that varying switch resistance was affecting the results obtained.

A decision was made at this stage to build a portable measuring unit to suit the particular requirements of the work. The unit is shown in Fig. 5, and a simplified circuit diagram in Fig. 6. It will be seen that one arm of each of the active and compensating gauge is switched, thus necessitating good quality switches. The switches used are "Uniselectors" manufactured by Ericsson Telephones. They have gold-plated contacts and wiper arms and are arranged for push-button electrical operation. Two ohm helically-wound balancing potentiometers are also included. This enables all the gauges to be balanced at the same instrument meter reading and thus the strains under load can be read directly, saving time on strain readings and eliminating the arithmetic. The unit caters for ninety-six active gauges and ten compensating gauges. Switch positions are shown by numbered indicator lamps, and the gauge leads are brought to the instrument through twelve pin plugs and sockets, each plug taking one twelve-core cable.

Where possible all items to be strain gauged are tested in an area of the laboratory set aside for this purpose. It is surrounded by canvas curtaining to prevent draughts affecting the gauges. The gauge leads are led from this area to an adjacent instrument room where all readings are taken. To take readings a team of two men only is required, one reading the instrument and operating the switch button and the other recording results on log sheets. It is possible in this manner to continuously measure over 600 gauges per hour.

As mentioned previously not more than ten compensating gauges are used for ninety-six active gauges. This has been found quite satisfactory for the particular type of work where active gauges are mounted in blocks and all quite close together. Dummies, for gauges mounted inside vessels to be pressurised, are not placed with the active gauges but are mounted on a separately waterproofed block which is immersed in a drum of water. This avoids the necessity of sealing cables and also any possible volume strain effect on the block on which the compensating gauges are mounted.

Where possible, strain readings for increments of load are taken, and these are graphed. The strain of any particular load can be taken from the graph, and the corresponding stresses calculated in the usual manner.

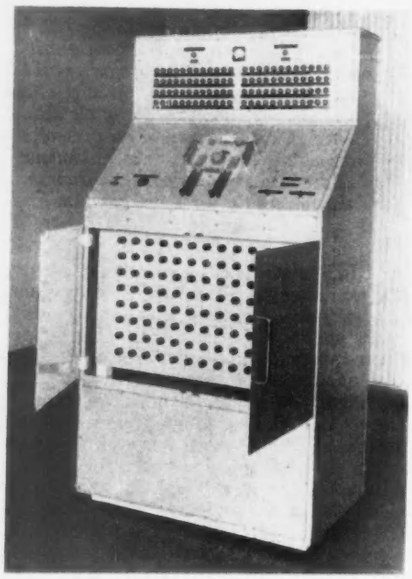


Fig. 5—Balancing and measuring unit

Having now reached a stage where it is considered that the practical aspects of static strain measurement have been mastered, techniques for high temperature stress analysis and measurement of vibration are being developed and several projects

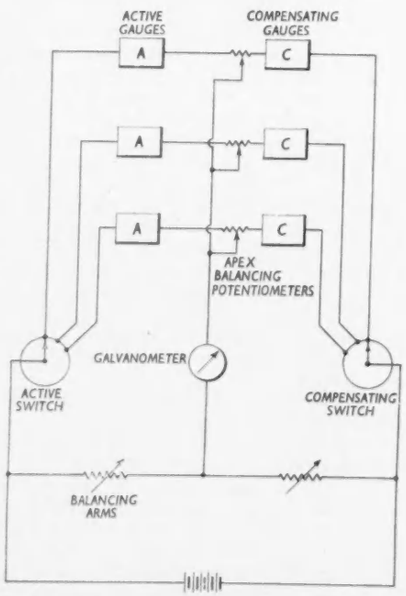


Fig. 6—Simplified wiring diagram for multi-channel strain gauge adaptation

of this nature have been undertaken. For this type of requirement and also for field work a more portable measuring unit is being built.

Recovery of Slip Power in Variable Speed A.C. Drives

A SCHEME for exploiting the slip power that would otherwise be lost in the rotor resistor of a variable-speed slipring motor has been developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

The basis of the scheme is to use silicon power rectifiers to rectify the alternating current circulating in the rotor resistance circuit and to apply the resulting direct current to a d.c. auxiliary motor (Fig. 1) which returns the power either directly to the main motor shaft (*a*) or indirectly, through a motor-generator set, to the stator winding of the motor (*b*).

Equipment for slip-power recovery can result in considerable economies in power consumption, particularly in drives where a large slipring motor is required to run for long periods below its top speed. In particular the savings may be significant in boiler feed pump and boiler fan drives and in mine ventilating fan drives. Because it uses silicon rectifiers the scheme described promises to be more attractive economically than earlier systems of slip-power recovery based on rotary converters or multi-anode mercury arc rectifiers with their associated transformers.

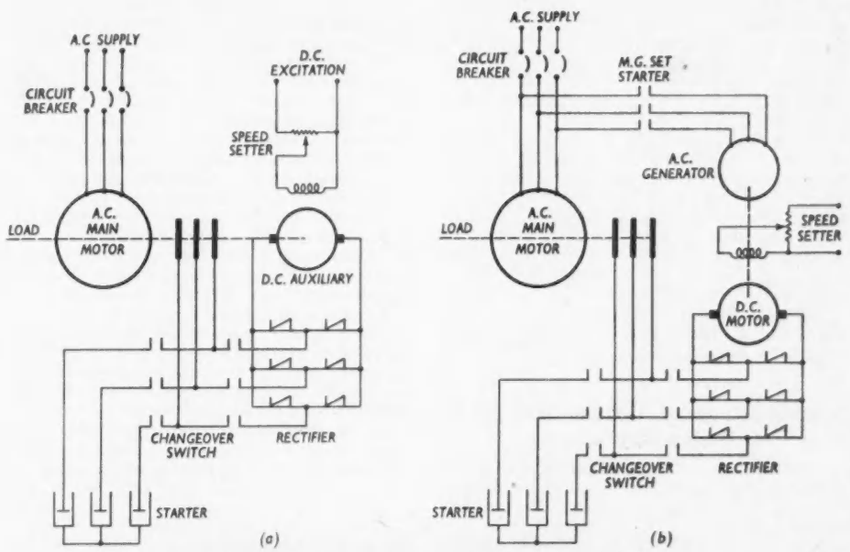


Fig. 1—Slip-power recovery by (*a*) direct drive, (*b*) indirect drive

Referring to Fig. 1 the sliprings of the main a.c. driving motor are connected to the terminals of a three-phase bridge-connected silicon rectifier which supplies current to a shunt wound or compound-wound d.c. motor of conventional design and construction. There are two alternative ways of recovering the power from this d.c. motor. In the first, (*a*) Fig. 1, the d.c. motor is coupled in tandem with the main a.c. motor and the recovered power is added directly to the main drive. In the alternative method, (*b*) Fig. 1, the d.c. motor is coupled to an induction generator which feeds electrical power to the stator of the main motor.

In general, method (*a*) is preferable for two reasons : first, it requires less additional plant ; secondly, at speeds below top speed the d.c. relieves the slipring motor of some of the load and thereby reduces the losses in it.

Special circumstances may tip the balance in favour of method (*b*) and some examples are given here.

1. In very-high-speed drives, such as boiler feed pumps, it may be impracticable to have the two motors direct-coupled and the choice would lie between the use of reduction gearing or the indirect recovery by method (*b*).

2. If the driven plant has to run over a wide speed range the required direct-coupled or geared d.c. motor might be unduly large in which event the alternative of a smaller, higher-speed d.c. motor driving an induction generator might be preferable.

3. Sometimes, as in a pumping station containing a standby pump, method (*b*) might be adopted because it would enable the slip-power recovery equipment to be switched from one drive to another.

The speed range and the power of the main drive determine the ratings of the slip-power recovery plant. The rectifier and d.c. motor must be designed for the maximum rotor current I_m and maximum slipring voltage V_m. But these maxima do not occur simultaneously: I_m occurs at the top speed of the main a.c. motor and V_m at the lowest speed. It follows that the cost of the slip-power recovery plant rises steeply in accordance with the speed range required of the main a.c. motor. If infrequent use is likely to be made of speeds well outside the normal speed range it may be advisable to limit recovery power to this range and to change to conventional control by variable resistance in the rotor circuit for other speeds.

Typical performance curves for a 1000 h.p., 735 r.p.m. fan drive are given in the diagram (Fig. 2). The curves can vary in shape depending on the speed range and load characteristic, but they show that over most of the speed range slip-power recovery yields a substantial saving in the power drawn from the supply system. At maximum speed, however, the losses in the auxiliary plant give a slight advantage to rotor resistance control.

With the slip-power recovery plant in circuit the maximum speed of the main a.c. motor approaches very closely the speed attainable with the sliprings short circuited, because the additional resistance in the rotor circuit is small, as a result of the high efficiency of the silicon rectifier and the elimination of the transformer. Moreover, the resistance drop in the d.c. motor armature can be compensated by injecting a small reverse field excitation to give a further increase in the maximum speed of the a.c. motor. This possibility may be attractive in drives where continuous control is required over the whole speed range, which means that short circuiting the sliprings for full-speed running would be undesirable.

Rectifier and Switchgear.—The rectifier equipment consists of a number of silicon diodes connected as a three-phase bridge and mounted in a cubicle. Cooling may be natural, forced-air or circulated water depending upon local requirements and the size of plant. Fault protection of the groups of diodes is given by fuses and by over-voltage relays. The switchgear is orthodox and includes a line circuit breaker and rotor starter for the a.c. motor, a rotor circuit changeover contactor, protective and interlocking relays, and a field supply rectifier and regulator for the d.c. motor. If the indirect method (*b*) is used an additional starter is needed for the motor generator set.

If the drive provides an essential service, rotor resistance control may be added, as a standby, with provision for automatic changeover in the event of a fault in the rectifier or in the d.c. circuit. When this standby system is provided the two regulators can be ganged to avoid any undue change in the speed of the a.c. motor at the instant of changeover.

Starting Operation.—The main a.c. motor is run up to speed in the usual way by the rotor starter. When the speed reaches a value within the normal speed range the slipring voltage will be less than the normal voltage rating of the rectifier and the slip-power recovery plant can then be connected into the rotor circuit. Interlocks prevent mal-operation.

If the d.c. motor is direct-coupled to the a.c. motor drive as in method (*a*) it may be advantageous to make use of the additional starting torque that is available from the d.c. machine. In that event the rotor starter would be connected between the sliprings and rectifier, to limit the current and voltage imposed on the rectifier during starting.

Speed Control of A.C. Motor.—Speed variation of the a.c. motor is effected by adjusting the field strength of the d.c. motor which is separately excited from an auxiliary rectifier (not shown in the diagram). Any change in the d.c. field strength alters the back electromotive force applied by the d.c. motor to the main rectifier of the slip-recovery plant. The speed of the a.c. motor then changes until its slipring voltage is sufficient to exceed this back electromotive force by the amount needed to maintain the required d.c. load current. Strengthening of the d.c. motor field causes a fall in the a.c. motor speed and weakening the d.c. field causes a rise in speed.

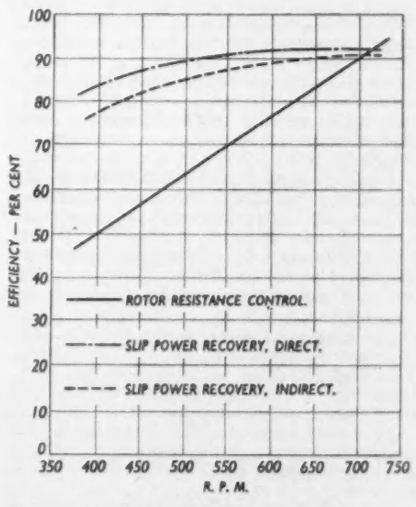


Fig. 2—Typical efficiency curves

With this system of control the a.c. motor has a typical shunt characteristic : the speed droops slightly as the load increases. The speed droop characteristic can be modified by including series turns in the d.c. motor field winding. Automatic control of the d.c. motor field and, therefore, of the main a.c. motor speed can be applied to either system (*a*) or (*b*).

SHORTER REPORTS

Two Important Road Schemes in London

CONTRACTS were announced last week for the construction of two major road improvement schemes in London, namely, the duplication of Blackwall Tunnel, and the scheme known as the "Hyde Park Corner to Marble Arch Improvement."

In the latter case a tender of £3,000,069 for all the road and tunnelling works was accepted by the L.C.C. from the consortium Cubitts–Fitzpatrick–Shand, whose member firms are Holland and Hannen and Cubitts, Ltd., Fitzpatrick and Son (Contractors), Ltd., and Lehane, Mackenzie and Shand, Ltd.

The scheme is well known, and a model of it has been widely exhibited. It comprises a four-lane underpass between Piccadilly and Knightsbridge built as two separate tunnels; a roundabout for the circulation of other traffic at Hyde Park Corner with a subsidiary roundabout north of Apsley House ; the conversion of Park Lane and the East Carriageway of Hyde Park for one-way traffic with connections so that together they form a twin carriageway outside the park with a wide central reservation ; roundabouts at Marble Arch ; and fifteen pedestrian subways.

A flexible plan for traffic while road works are being carried out and a programme for the phasing of the work have been agreed upon. Work is expected to begin on May 1, and will take twenty-eight months to complete. It will be carried out by the contractor under the direction of the Council's chief engineer, Mr. J. Rawlinson, M.I.C.E. Mr. H. Iorys Hughes has prepared the design drawings and bills of quantities for the underpass and subways. The laying out of the islands and the central reservation designed by the architect to the Council, Hubert Bennett, F.R.I.B.A., will, the L.C.C. states, "provide a practical and pleasant setting for the three main areas around which the traffic will circulate." Brief details were given earlier in THE ENGINEER of April 26, 1957, page 631, and the sewer diversion at Hyde Park Corner was described in the issue of March 20, 1959.

Blackwall Tunnel Duplication Scheme.—The scheme for duplicating the Blackwall Tunnel is also of long standing, and was described in these columns on May 2, 1958, and May 8, 1959. the latter note concentrating on the method of tunnel construction to be employed, and the particular tunnelling problems encountered.

The tender of Balfour, Beatty and Co., Ltd., has been accepted for the tunnelling work. The contract price is £3,935,799 for work, comprising the construction of the cast iron lined portion of the new tunnel—a length of 2850ft—with working shafts, pilot tunnels and ancillary caissons ; it will begin early in April, and is estimated to take forty-two months to complete.

The new tunnel will be situated approximately 250 yards downstream of, and roughly parallel with, the existing Blackwall Tunnel and will consists of a cast iron tube with an internal diameter of 28ft 2in accommodating a two-lane carriageway 20ft wide, with footways for maintenance only. When the new tunnel is completed there will be a one-way traffic system ; north-bound traffic will use the existing tunnel and southbound traffic the new tunnel.

Messrs. Mott, Hay and Anderson (for whom Mr. J. Kell, A.C.S.M., is the partner dealing with the scheme) are responsible for the work in association with the London County Council's chief engineer, Mr. J. Rawlinson. The remainder of the works not covered by this contract, include the construction of the shallower end sections of the tunnel, the north and south approaches, the lining, ventilation and lighting of the tunnel and drainage pumping plant. They will be carried out under the direction of the Council's chief engineer and will take a further period of approximately eighteen months to complete.

The L.C.C. town planning committee's report points out that seven firms were invited to tender for the tunnel. Six tenders were received, varying in price from the lowest, which was accepted and is quoted above, to a sum of £4,823,099, and with completion times from thirty-six to fifty-four months. The appointed engineers' comparable estimate was £5,076,661, and it is considered that the favourable tender may be attributed to the keen competition fostered by the scheme.

Atomic Energy Irradiation Conference, Sydney

THE Australian Atomic Energy Commission is to hold a conference on the technological use of irradiation, at the University of New South Wales, from May 23 to 25, 1960. The object of the conference is to review recent developments and stimulate interest in research and applications of irradiation. It is intended to cover the following topics : food preservation ; sterilisation of medical and pharmaceutical supplies and of industrial raw materials ; the promotion of chemical changes such as polymerisation ; insect pest control and the genetics of plants.

Papers are invited for presentation at the conference ; they may give general reviews of developments or cover work done in specialised branches of the subject. Prospective authors should note that the titles of all papers, together with summaries of the contents, should be received by April 14, by The Irradiation Conference Secretary, A.A.E.C. Research Establishment, Sutherland, New South Wales, Australia.

Delegates to the conference will be able to visit A.A.E.C. Research Establishment at Lucas Heights on May 23, 1960.

Second Stage of Birmingham–South Wales Motorway

CONSTRUCTION of 12½ miles of motorway, extending from the southern outskirts of Birmingham at Lydiate Ash to a point about a mile north of Warndon in Worcestershire, is to start shortly, and should be completed within eighteen months. The tender of A. Monk and Co., Ltd., amounting to £3,860,335, has been accepted for the work. This length of motorway will form a second section of the route from Birmingham to South Wales, which was started in 1958 with the construction of the Ross Spur motorway. It includes fourteen bridges over or under roads, bridging the Birmingham–Worcester Canal at Offerton, and the Birmingham–Worcester railway east of Droitwich.

The motorway will have two 24ft carriageways, separated by a central reservation 15ft wide. Excavations amounting to about 2,000,000 cubic yards of earth and rock will be necessary. The works have been designed for the Ministry of Transport by the agent authority, Worcestershire County Council, (county surveyor, Mr. W. R. Thomson, M.I.C.E.).

A. Monk and Co., Ltd., is expected to be awarded a £3,749,694 contract for a proposed further 15 miles of the motorway passing east of Worcester to join the Ross Spur once certain difficulties over the acquisition of land are settled. Work will, however, start immediately at the northern end of the contract on a length of 5½ miles. The route for a further extension of this motorway, from the junction with the Ross Spur, southwards to Bristol, is now being surveyed in detail.

Seventh International Congress on Large Dams

THE International Commission on Large Dams, which is a body affiliated to the World Power Conference, has announced a provisional programme for the seventh international congress on large dams. The congress is to be held in Rome from June 26 to July 9, 1961. As customary, "study tours" of dams, hydro-electric power stations, and so on throughout Italy and Sardinia have been arranged to follow the congress. The technical programme is grouped under four "questions" as follows : question 24, the selection, processing and specification of aggregates for concrete for large dams ; question 25, underground work in connection with large dams ; question 26, modern techniques for concrete dams for wide valleys, and ancillary works ; and question 27, sealing earth and rockfill dams with bitumen and other materials.

Electricity Bulk Supply Tariff, 1960–61

THE Central Electricity Generating Board states that in accordance with its policy to hold down electricity prices, the 1960–61 Bulk Supply Tariff to the Area Electricity Boards (which are responsible for supplying domestic, industrial, farm and commercial consumers) will, for normal supplies, be the same as that for 1959–60. The normal kilowatt charge, therefore, remains at £7 2s. and the running charge at 0·41d. per unit (with a variation according to fuel costs).

An interesting innovation in the 1960–61 tariff is the introduction of special terms for loads which can be restricted by the Generating Board during short peak load periods. A rebate of £3 19s. on the normal kilowatt charge will be allowed to the Area Electricity Boards for such loads. To qualify for the special terms, which will be subject to agreement between the consumer, the Area Board and the Generating Board, the special consumer must be connected directly to a power station or substation of the Generating Board and must have a demand which can be restricted by not less than 25,000kW. The object of this concession in the tariff is to help to improve the load factor of the supply system.

Moscow International Congress on Automatic Control

As the British member body of the International Federation of Automatic Control (I.F.A.C.), the British Conference on Automation and Computation has, during the past year, selected twenty-eight papers to form the British contribution on the subject of automatic control for presentation at the first International Congress on Automatic Control in Moscow, from June 27 to July 7 next. Arrangements for this congress are being undertaken for I.F.A.C. by the U.S.S.R. National Committee for Automatic Control. The total number of papers to be presented is 282, and twenty countries are represented. An official British delegation of engineers and scientists will be led by Mr. John F. Coales, of the University of Cambridge. As the number of places at the Congress is limited, any further applications should be sent without delay to the Honorary Secretary, Group A, B.C.A.C., c/o the Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1 ; estimated cost of conference fee, travelling and subsistence is of the order of £200 per delegate. The British papers presented at the congress are to be re-presented in this country in September, and details concerning this will be published by B.C.A.C. very shortly.

BEAMA Annual Report

THE annual report for 1959–60 of The British Electrical and Allied Manufacturers Association (BEAMA), 36, Kingsway, London, W.C.2, was presented at the annual meeting of the Association in London on March 17. The report shows that the output of the industry reached a value of about £1400 million in 1959—an increase of about 9 per cent above the output for 1958. Domestic electric appliances accounted for the most significant part of this increase in production and the output for the first three quarters of the year exceeded the whole of the 1958 output. In heavy electrical plant deliveries of steam turbo-alternators reached a record total of nearly 4000MW, which included the first 200MW set to be commissioned by the Central Electricity Generating Board. Among the orders placed by the C.E.G.B. were those for 300MW and 350MW sets, which are the largest single-shaft designs planned and the second 550MW cross-compound set for Thorpe Marsh power station was also ordered.

At the request of the BEAMA council its director has prepared a report to form a basis for the future policy, form and functions of the Association, bearing in mind competitive conditions throughout the world and the effect of the Restrictive Trade Practices Act. This report emphasises that the declared objects and basic organisation of BEAMA are well suited to the tasks and opportunities ahead. However, it is proposed to develop and extend the Association's facilities to meet the future needs of members in the field of standards, in overseas trade and in a comprehensive statistical and information service. In this connection the report recognises that one of the chief causes of excessive price warfare is lack of information about turnover, price levels and costs.

Domestic Appliances Division.—Recognising the growing importance of domestic uses of electricity the council has formed a Domestic Appliances Division of BEAMA, with its own board under the chairmanship of Mr. W. J. Bird. Largely through the efforts of this board proposals have been formulated for setting up a suitable body for the testing and approval of domestic electrical appliances. A scheme has been worked out and agreed with the electricity supply industry, the British Standards Institution, electrical contractors, wholesalers and retailers, which has resulted in the setting up of a provisional British Electrical Approvals Board for domestic appliances. This board is intended to be independent of vested interests, including those of manufacturers and the electricity supply industry. It will take over from the Electrical Development Association the existing list of approved appliances and will institute procedures for testing and approval of appliances and the issue of a suitable mark of approval.

In response to an approach by the Board of Trade to the BEAMA, the Domestic Appliances Division has assumed responsibility for organising the collection and publication of statistics relating to domestic electrical appliances, on behalf of the whole manufacturing industry.

Exports.—The BEAMA report shows that electrical and allied exports reached a record total of £285 million in 1959, an increase of 3·2 per cent over the previous year. The main gains were £4,000,000 in turbine plant and £1,600,000 in electric motors. Amongst the leading markets were, first, India, which supplanted Australia (now second) followed by South Africa, the U.S.A., Canada, New Zealand and Rhodesia, in that order. Exports to the North American continent totalled £30,000,000, or more than 10 per cent of the total.

The BEAMA view, as expressed through the Federation of British Industries, is that, for the electrical industry, the full benefit of the creation of the European Free Trade Area (E.F.T.A.) can only come through an eventual association with the European Economic Community (E.E.C.) or "Common Market."

Technical Education.—The BEAMA has welcomed the establishment of the National Council for Technological Awards and recognises the value of the Diploma of Technology and the higher award of Membership of the College of Technologists. On the other hand BEAMA, as spokesman for the electrical manufacturing industry which pioneered the system of technical training through the "sandwich course," considers that a higher standard of technical training should be required for the Diploma of Technology. Representations have, therefore, been made to the Hives council, stressing the view that the technological training part of the "sandwich course" should be judged to be just as important as the academic part.

Proposals for establishing a Readership in Electric Traction Engineering at the Imperial College of Science and Technology have been agreed in principle, and BEAMA is to give financial support for an initial period of seven years.

Electronic Forum for Industry.—An Electronic Forum for Industry, with BEAMA as a founder member, was formed last year to co-ordinate the work of the trade associations that are concerned with electronic engineering, including such applications as office appliances and computers. Two open meetings have been held, at which papers on the use of electronic computers in industry were read and a third meeting is to be held in conjunction with the forthcoming Instruments, Electronics and Automation Exhibition, May 23 to 28.

Nuclear Energy Trade Associations' Conference.—The BEAMA has continued to foster the interests of member firms on the governing body of the Nuclear Energy Trade Associations' Conference (N.E.T.A.C.). One of N.E.T.A.C.'s main tasks is that of organising publicity and trade fair exhibits on a collective basis on behalf of the consortia of firms interested in atomic power plant. In this connection a British section has been organised at the International Instruments and Measurements Exhibition to be held in Stockholm in September next. The United Kingdom Atomic Energy Authority intends to show reactor exhibits, instrumentation, a reactor simulator and radioactive isotopes, and it is hoped that the whole of the lower ground floor of the exhibition building will be filled by British exhibits.

Materials.—The Association has made representations to the Iron and Steel Board with regard to the continuation of the temporary exemption from import duty of mild sheets bought overseas. As a result, this exemption has been extended until the end of this year, which will allow member firms to programme marginal purchases from overseas sources over a longer period than hitherto. However, in view of the buoyant demand for steel sheets the BEAMA committee has estimated that the demand is likely to increase by 20 per cent per annum for the next four or five years and has asked for the exemption from import duty to be further extended, say, to the end of 1963.

Quantitatively, the supply of cold-reduced oriented, electrical transformer sheet is considered to be adequate but the BEAMA report says that transformer makers are not fully satisfied with the quality; discussions of these difficulties are being arranged with suppliers.

Expansion of British output of large extra-high-tension insulator porcelains has ended the need for imports of these products and the relevant import duties exemption order was rescinded on July 1, 1959.

British Railways Electrification Conference

OVER forty papers on technical aspects of the 25kV a.c. system of railway electrification will be presented at the British Railways Electrification Conference in London in the first week of October, of which a preliminary announcement appeared in our August 21, 1959, issue. The conference will be supported by an exhibition of electric locomotives and traction equipment at Battersea from October 3 to 9.

The opening paper of the conference will be given by Mr. S. B. Warder, Chief Electrical Engineer, British Railways Central Staff, British Transport Commission, under the title "Electrification in the Modernisation of British Railways; The choice of the 50-cycle System." This will be followed during the week by ten papers read by the authors, while the remaining papers, which will be printed and distributed, will be discussed but not read at the conference. Papers are being prepared by technical officers of the Commission and the railway Regions, as well as by the directors, chief technical managers, engineers, or designers, of many well-known manufacturers in the British industry. The subjects will range over locomotives and multiple-unit trains, power supplies and distribution, civil engineering, interference problems, signalling and telecommunications, instrumentation and measurement, switchgear, and the catenary overhead system. The summing up will be by Mr. R. C. Bond, Technical Adviser to the Commission.

The titles and authors of the ten other papers to be read at the conference are as follows:

"The Application of the 50-Cycle System as proved by System Tests," by J. A. Broughall, Electrical Engineer (Development), B.R. Central Staff; and F. J. Lane, Preece Cardew and Rider.

"The Locomotives," by E. S. Cox, Assistant Chief Mechanical Engineer, B.R. Central Staff; and G. G. Kibblewhite, Assistant (Rolling Stock Equipment), Chief Electrical Engineer's Department, B.R. Central Staff.

"The Multiple-Unit Trains," by H. Willcock, Design Engineer (Standards), Chief Mechanical Engineer's Department, B.R. Central Staff; and C. J. Clemow, Senior Technical Assistant, C.E.E. Department, B.R. Central Staff.

"The Power Supply," by W. J. Webb, Assistant Electrical Engineer (Systems), C.E.E. Department, B.R. Central Staff.

"The Overhead Line Equipment," by E. Claxton, Assistant Electrical Engineer (Development), C.E.E. Department, B.R. Central Staff.

"Civil Engineering Aspects," by A. K. Terriss, Chief Civil Engineer, Eastern Region, B.R.

"The Interference Problem," by H. R. J. Klewe, Senior Technical Assistant, C.E.E. Department, B. R. Central Staff.

"Signalling and Telecommunications," by A. W. Woodbridge, Chief Signal Engineer, B.R. Central Staff.

"Research for A.C. Traction," by F. T. Barwell, Electric Traction Engineer (Research), B.R. Central Staff.

Among the remaining papers, nine will deal with specific series of locomotives or motor coach stock under construction or already operating on British Railways, five with power supply, four with overhead equipment, one with signalling equipment, and one with pantographs.

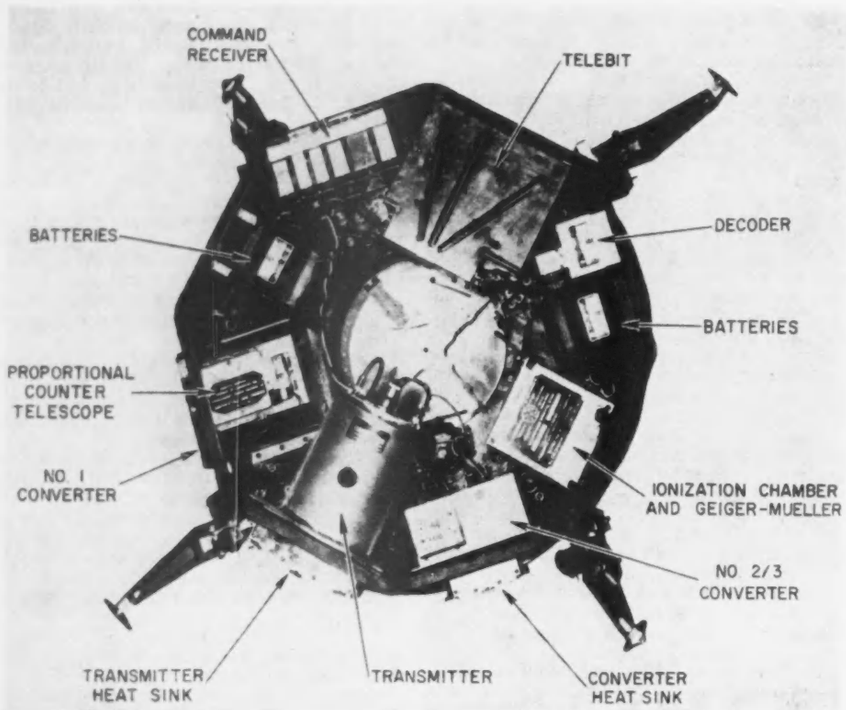
All papers will be printed and distributed beforehand to delegates attending the conference. Later these papers will be printed in full in the bound proceedings, which will also include the full discussion on each paper. Preliminary orders for the proceedings may now be placed with the Secretary of the British Railways Electrification Conference, B.T.C. Headquarters, 222, Marylebone Road, London, N.W.1.

Power Signalling at Edge Hill

WORK has begun on a new power signalbox at Edge Hill, Liverpool, in the London Midland Region of British Railways, which will supersede four existing boxes in controlling the station area and the approaches from Olive Mount Junction and Allerton Junction, on the lines from Manchester and Crewe respectively. The relay interlocking control panel will be the first in the London Midland Region to embody the principle of route-setting by operating two push-buttons per route, one at its beginning and the other at its end (entrance-exit working). The panel is being supplied by the Westinghouse Brake and Signal Company, Ltd., and will incorporate the company's "push-push" system of operation with buttons on a track diagram, as described in connection with Southern Region installations in our December 25, 1959, issue.

The new power signalling, with colour-light signals, continuous track-circuiting and electro-pneumatically operated points, will completely replace the existing mechanical signalling in the area. This installation, in conjunction with extensive track remodelling and the transposition of the running lines between Edge Hill and Liverpool Lime Street, will provide for a freer flow of traffic in and out of the terminal and is part of the larger plan for improved signalling and electrification of the running lines between Crewe and Liverpool.

SHORTER REPORTS *(Continued)*



Top of apparatus platform within "Pioneer V." The magnetometer, meteoric dust detector and aspect sensing device are on the reverse side

Equipment of "Pioneer V"

SOME of the equipment inside the American "Pioneer V" satellite, to the successful launching of which we referred last week, is shown in the first of the accompanying illustrations.

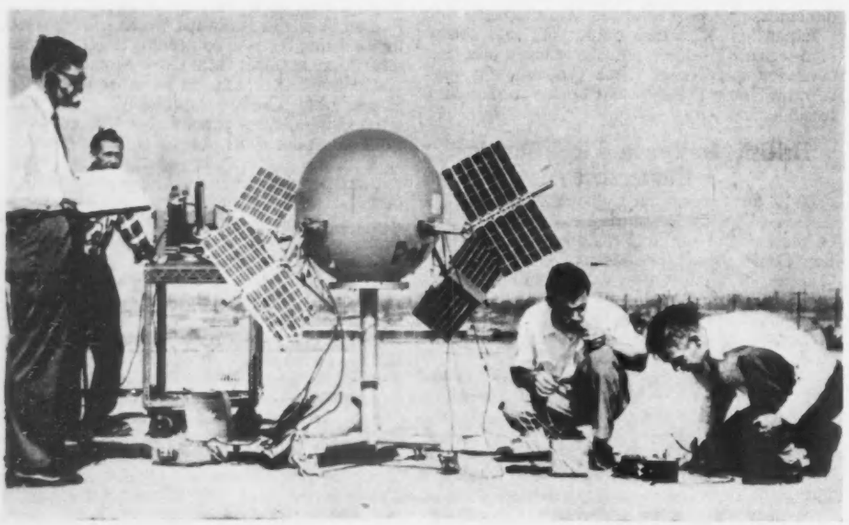
The experiments being undertaken while the probe is in orbit include the measurement of high-energy, or "hard," radiation, particularly that proceeding from the sun. These investigations are of particular importance because no previous probe has had an orbit so close to the sun. The counter consists of six argon gas cylinders ranged round a seventh cylinder, the complete assembly measuring about 2in square. Inbound particles ionise the gas in one or more cylinders according to their energy and produce proportional electrical impulses. This device weighs 5 lb. It has been developed by the University of Chicago.

An ionisation chamber and Geiger-Mueller tube are carried to measure the total ionisation flux encountered. They are particularly sensitive to medium-energy radiation. These instruments were supplied by the University of Minnesota. Together the instruments weigh about 2 lb and are contained in a box 4in square.

A micrometeorite device was developed for the probe by the U.S. Air Force Cambridge Research Centre. Its purpose is to measure the number and momentum of meteoric dust particles striking the probe. The entire unit weighs less than 1 lb and consists of a diaphragm, about twice the size of a playing card, mounted on the skin of the probe, and an internal microphone. The sound of impact is translated into electrical impulses for transmission to earth.

The search-coil magnetometer in the probe was developed by Space Technology Laboratories, Los Angeles, California, and weighs 1 lb. The same organisation developed the 8 oz. photocell aspect indicator which detects the attitude of the probe relative to the sun, initiating an electrical pulse when looking directly at it. These "fixes" on the sun will be of value in studying information from the magnetometer and radiation counter. The magnetometer, micrometeorite electronics and aspect detector are mounted on the reverse side of the platform illustrated.

Some details of the radio equipment in the probe were given in our March 18 issue and it will be recalled that information is stored between transmissions, this taking place in the "telebit" seen in one of the accompanying illustrations. The second illustration shows tests in progress on the silicon solar cells used for charging the internal batteries, the "paddle wheels" containing the cells being here attached to a mock-up of the actual probe.



"Paddlewheel" arrangement of solar cells attached to mock-up of satellite for output tests

Miniature Potentiometric Recorder

A PANEL cut-out of only 9⅝in by 8¾in is required for the new "Hi-Speed" miniature self-balancing potentiometric recorder of Control Instruments, Ltd., Tower Building, Liverpool, 3, a member of the Vernon Engineering Group. These reduced dimensions, combined with an overall case size of 10¾in by 10in by 12in deep, are stated to be the result of simplifications in mechanical and electrical design, including the electronic self-balancing system. The recorder compares the voltage signal from a transducer with an internal stabilised d.c. reference potential developed in a potentiometer circuit, and any error is converted into approximately sine wave alternating current by a vibrating reed chopper followed by a centre-tapped toroidal transformer. After amplification in a four-stage, high-gain amplifier, the signal is applied to one phase of a two-phase motor, having its second phase fed with a constant reference voltage from the mains. Since the signal voltage leads or lags the mains reference, according to the sense of the original error, the motor rotates in the appropriate direction to restore balance by adjusting the potentiometer, and in so doing drives the recorder pen. The calibrated chart width is 6in.

[Reply Card No. E5322]

Capacitive Transducer System

WE witnessed recently a demonstration of a capacitive transducer and probe assembly introduced by Racal Instruments, Ltd., Bracknell, Berks, for counting and batching, level control, speed measurement, vibration analysis and similar applications. In the counting application demonstrated, the probe and transducer are placed in proximity to a toothed wheel on a rotating shaft and by sensing the variation of capacitance caused by the passage of the teeth, the transducer frequency-modulates the output of a 1·2 Mc/s oscillator in the supply unit. A discriminator produces a d.c. voltage directly proportional to the changing capacitance, this taking the form of pulses which are amplified in the supply unit for counting. At the demonstration the supply unit fed directly into a Racal digital frequency meter. With this system satisfactory operation is obtained whether the object under test is of conducting or non-conducting material, which may be in the form of solid, liquid or a powder. We were informed that adequate responses have been obtained when detecting changes of capacitance due to painted stripes on a revolving shaft. The probe and transducer assembly measures 2½in long and ⅞in in diameter, and weighs 1¼ oz. Dimensions of the supply unit are 4in by 3in by 2in.

[Reply Card No. E5323j]

Data Processing System Development

CONSIDERABLE improvements in speed and flexibility of data processing are announced by I.B.M. United Kingdom, Ltd., 101, Wigmore Street, London, W.1, in connection with the introduction of a transistorised development of the I.B.M. 705 computer. The new system, known as the I.B.M. 7080, is stated to be six times as fast as any previous I.B.M. commercial computer, but at a substantially lower job cost. The new system can read from, and write on, up to five independent magnetic tapes simultaneously, each at the rate of 62,500 characters per second and, at the same time, perform internal computation and the transfer of data. The main storage consists of up to two units of magnetic core storage (each with an access time of 2·18 microseconds) which, together, can hold 160,000 characters of information. In addition, there is an auxiliary storage of 1024 positions, with an access time of 1·09 microseconds.

Although existing 705 programmes can be accepted by the 7080 as they stand, the 7080 has fifteen additional instructions which new programmes can use. In particular, these enable the 7080 to perform two independent programmes simultaneously under a method of priority processing which enables any machine component which might be momentarily idle, if concerned only with a single programme, to be usefully employed. Card readers, punches and printers for the 705 can be used with the 7080, together with up to fifty magnetic tape units. The 7080 requires only 50 per cent of the air conditioning and power of the 705 and 30 per cent less space.

[Reply Card No. E5331]

Light-Operated Switch

INDEPENDENT adjustment of the "on" and "off" settings is provided in the photo-electric lighting control switch illustrated, of which we have received details from Londex, Ltd., Anerley Works, London, S.E.20. Light falls on the internal photocell through the glass dome on top of the case, and the amplified output operates a relay rated at 3A, 250V a.c. Currents up to 60A can be handled by using an external mercury switch relay. The switch can be set

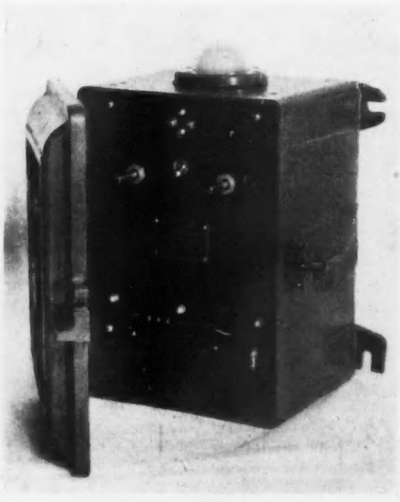


Photo-electric lighting control switch with individual "on" and "off" setting adjustments

up to control lighting or other electrical circuits according to the level of daylight. Adaptability to different installations is achieved by the independent "on" and "off" adjustments. Site conditions may make it economical to switch on lighting at a lower level than it is switched off or vice versa, and both requirements may be met; or two blocks of lighting in different parts of a building may need to be brought into operation at different levels of illumination according to the nature of the areas they serve and the work performed in them. Experience has shown that the range of adjustments required varies from quite narrow to wide limits and the D.C.R. night/day switch has been designed to provide these facilities in a unit of moderate price. Two models are manufactured, D.C.R.1 having an adjustable range from 0·2 to 5ft-candles and D.C.R.2 from 2 to 50ft-candles. Access to the screwdriver adjustments of the setting potentiometers is obtained through apertures in the cover which are normally sealed by screw plugs.

All components are mounted on a printed circuit board fixed behind the insulated front panel. Normally the output contacts operate approximately thirty seconds after a preset intensity has been reached in order to prevent unnecessary switching during short changes of daylight intensity, but this delay can be cut out when required, as for setting up the unit.

[Reply Card No. E5332]

Beryllium Monitor

A FULLY automatic beryllium monitor designed to give, within sixty seconds, warning of any increase in the concentration of beryllium in the air of workshops or laboratories has been developed at the Chemistry Division (Woolwich) outstation of the United Kingdom Atomic Energy Research Establishment. Because of the toxicity of beryllium and its compounds it is necessary to ensure that beryllium concentration in air should be kept below two millionths of a gramme per cubic metre. The main advantage of the apparatus developed by the A.E.R.E. is that it gives rapid analyses.

The air to be sampled is drawn through a specially designed chamber in which any beryllium present is optically excited as it passes through a triggered alternating-current arc. The ultra-violet radiations from this source are then resolved into their components by means of a small spectrograph which is specially designed to have a high dispersive power. The intensity of the beryllium doublet at 3130A, which is proportional to concentration of beryllium present in the air being monitored, is measured photo-electrically and then recorded on a chart.

The apparatus is fully automatic and it will operate on a predetermined cycle in which it is first calibrated and then records a series of results, at one minute intervals. The results produced are quantitative over the range of concentration from 1 to 75 millionths of a gramme of beryllium per cubic metre. The sensitivity of the instrument is stated to be comparable with other designs and it is not affected by the chemical form of the beryllium entering the monitor or by the sizes of particles normally present in atmospheric dust.

This monitor could be used for the determination of a number of elements apart from beryllium, and it is considered to have potentialities in the monitoring of atmospheres for such elements as mercury, lead, chromium, manganese, silicon, arsenic, antimony, zinc and copper.

[Reply Card No. E5333]

Flexible Plastic Pipelines

A NOTE from British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1, states that it has further developed a range of flexible, reinforced plastic pipelines to meet the requirements of off-shore oil operators. This form of pipeline consists basically of an inner plastic tube reinforced against internal pressure by a helical winding of steel tapes which are protected against corrosion by an outer plastic sheath. Pipes are available with bores of 1½in to 4in and suitable for operating pressures up to 3000 lb per square inch. A maximum continuous length of some 15 miles can be manufactured although normally the pipes are supplied on reels in shorter lengths up to 18,000ft, according to bore and operating pressure.

The smooth internal surface of these pipes offers a low resistance to fluid flow and does not tend to cause encrustation with paraffin wax when oil is conveyed. They are extremely inert and resistant to aliphatic and low aromatic content hydrocarbons and are generally corrosion resistant. The makers say that joints and terminals can quickly and easily be fitted to the pipelines by unskilled personnel using parts and materials supplied in packs. In tropical and sub-tropical waters where there is a menace from the toredo worm, the pipelines can be supplied with a further protection of two bronze tapes and another plastic sheath.

[Reply Card No. E5334]

Blast-Furnaces at Stanton

THE No. 5 blast-furnace at the Stanton works of the Stanton Ironworks Company, Ltd., has been relighted after being out of commission since last September for repair and relining. The hearth diameter of the furnace has been increased from 16ft 6in to 19ft and the furnace has been equipped with underhearth cooling. In addition, the stack volume of the furnace has been increased by using a thinner lining built in low porosity firebrick; the bricks have been laid in a spiral design to obviate loss of time in fitting closure bricks necessary in the conventional method of furnace lining. When fully in commission, the furnace is expected to produce from 2500 to 3000 tons of pig iron a week. We are informed that for the first time since January, 1957, all the five furnaces at Stanton are now in blast.

Wet Cyclone Dust Collector

A DUST collector combining centrifugal and wet collection in the same unit is being manufactured under licence by the Visco Engineering Company, Ltd., Stafford Road, Croydon, Surrey. The design, which was developed by Jakob Handte and Co., Tuttlingen (Württ.), is claimed to be virtually 100 per cent efficient for particles over 4 microns, and 89·5 per cent efficient for particles between 1 and 1·5 microns, provided they show an affinity for water.

Each unit is self-contained and can be grouped with others according to the air volume which is to be handled. It comprises a cylindrical steel casing, removable sludge disposal bin, built-in cyclone and water eliminator, the whole surmounted by a vertical exhaust fan directly driven by an electric motor. The unit is equipped with floor-mounting supports, water connections for filling, and a hose for periodical cleaning. For a large group of units, centralised sludge disposal can be employed.

The air vortex induced by the fan serves to deposit the heavy particles in the water filling the bottom of the unit. As the air current sweeps upwards into the central tube of the cyclone, it carries with it a spray of water which wets the remaining fine dust particles with which it comes into contact. The dust and droplets are then separated out in the centrifugal water eliminator, and the clean air is discharged. The collector is stated to be free from fire risk, even when handling incandescent or explosive dust. It is manufactured in a range of sizes from 300 to 5000 cubic feet per minute.

[Reply Card No. E5335]

Effluent and Water Treatment Exhibition

THE first "Effluent and Water Treatment Exhibition" is to be held at the Seymour Hall, London, W.1, on October 18 to 21 this year. It is expected that a wide range of equipment, plant, and techniques will be exhibited covering this important field. Simultaneously, a convention will be held with the co-operation of a number of societies and institutions specialising in effluent and water treatment problems, at which papers will be presented.

The subjects covered by the convention will include: analysis techniques; biological effluent treatment; boiler feed waters; composting treatment; development of filtration and water treatment plant; discussion of the Armour committee report; electro-precipitation of industrial mists and dusts; fluoridation; manufacturers' problems in disposing of effluents and trade wastes; problems of design in effluent system plant; pumping; river pollution; sewage disposal without main drainage; treatment of radio-active waste materials; waste water recovery; and water softening.

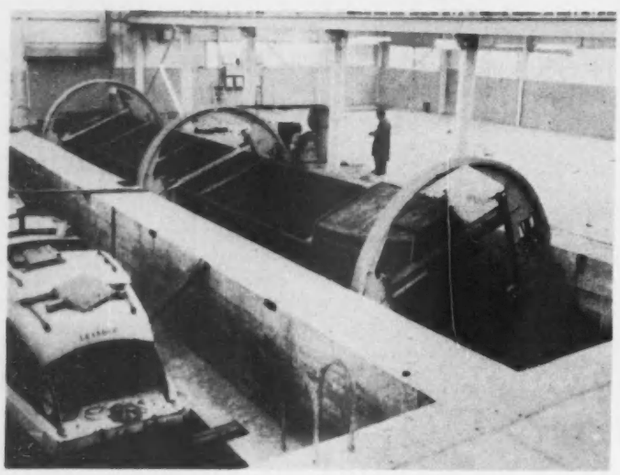
SHORTER REPORTS *(Continued)*

Barge Manipulator

BRITISH WATERWAYS has recently built inside a workshop at Bilston, Staffordshire, a new dry dock for the docking of barges and for carrying out regular inspection and maintenance work. To assist in this and to expedite the work, Donald Ross and Partners, Ltd., Crawley, Sussex, has designed, supplied and installed mechanical handling gear which is intended to position the barges for inspection purposes and for effecting repairs. The equipment, seen in our illustration, is permanently fitted in the dry dock, into which the barges are floated through a lock gate at the workshop door from a basin, and consists of three large ring assemblies. These are supported on steel roller beds grouted into the floor of the dock and by rubber-tyred rollers in the dock walls. To obviate corrosion, the shafts of the steel roller beds are of stainless steel and are carried in "Tufnol" bearings. All three rings are connected to a long steel fabricated beam upon which the barge settles after it has been floated into the manipulator and the dock emptied. Screw-operated clamps are then used to secure the barge within the rings.

When secured, the barge can be rotated for examination and for carrying out repairs: the rotary movement is effected by a winch, located at mid-length of the dock, which drives a sprocket wheel and a conveyor pattern chain which is wrapped around the centre ring assembly. When repaired, the barge is returned to its normal position, clamps are released and the dock flooded ready for floating out. The barges handled are generally about 70ft in length and weigh up to 9 tons.

[Reply Card No. E5341]



Barge manipulating installation at Bilston

"Oswald" Thermonuclear Apparatus for the Science Museum

"OSWALD," an apparatus used in early work on controlled thermonuclear reactions, is being sent on permanent loan to the Science Museum from the Atomic Weapons Research Establishment (A.W.R.E.), Aldermaston. The machine has been partly dismantled and its components labelled to enable the non-technical visitor to understand how it works. It is expected to be on view in the Science Museum within two to three weeks.

Basically, "Oswald" consists of a condenser bank and switchgear capable of delivering an extremely heavy current in a very short time to a straight quartz discharge tube containing a gas under low pressure. The idea was to put electrical energy through the gas in the discharge tube as rapidly as possible so that a temperature of several million degrees could be reached before cooling processes and instabilities could operate. The gas was heated by magnetic compression which required a rapid rate of rise of the current. However, condenser banks had hitherto been discharged by a single switch which limited the rate of rise. A considerable experimental advance was made by using 144 spark-gap switches in parallel, all operating within a few thousand-millionths of a second.

Neutrons were produced by a gas discharge in "Oswald" in February, 1957—the first time this had been achieved in Britain. The temperature reached was estimated to be around 1,000,000 deg. Cent.

The method of obtaining high temperatures pioneered by the designers of "Oswald" is known as rapid compression heating. It is now being studied with multi-switch banks in many nuclear research laboratories throughout the world. The largest of these devices in Great Britain is known as "Maggie" at A.W.R.E.; it is capable of providing a current with a of rise of 5,000,000 million amperes per second, or about four times the rate of rise in "Oswald."

Hand Tools

Two recent additions to the hand tools in the "Steadfast" range made by J. Stead and Co., Ltd., Manor Works, Cricket Inn Road, Sheffield, 2, are a 6in ratchet screwdriver and a pocket padsaw set. The ratchet screwdriver is fitted with a handle of translucent plastic shaped to provide a comfortable pistol grip. This grip has at the inner end a projecting pad against which the finger registers, and its shape is designed to increase the effort which can be exerted in screwing and unscrewing operations.

The new padsaw also has a plastic handle shaped to fit comfortably in the hand and is provided with two saw blades and a knife edge cutter blade. Replaceable coarse and fine tooth blades provided with this tool suit it for sawing both soft and hard materials.

[Reply Card No. E5343]

Industrial Films

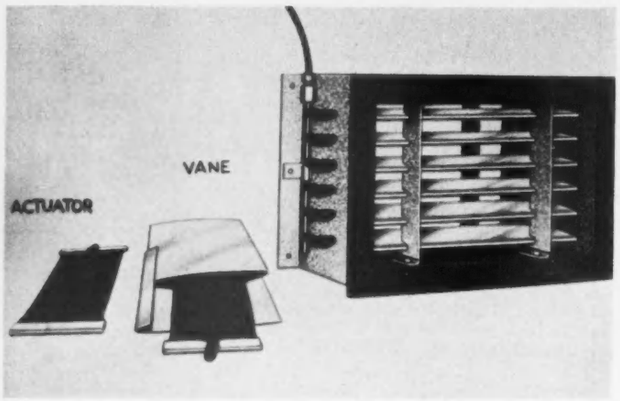
A NEW educational film produced by Edward Lloyd in Eastman colour for Concrete, Ltd., entitled "Precast Concrete," was shown for the first time in London last month. The film was made, it is stated, to encourage the use of precast concrete by demonstrating new techniques which have recently been introduced and which are now accepted practice in the building and civil engineering industries. The film consists, for the most part, of specially edited excerpts from detailed sequences of construction shot in all parts of Britain and shows current trends. The use of precast H-frame construction is shown and examples of *in situ* and precast frame construction are compared. Developments in prestressed precast concrete bridge construction and in frame construction are also illustrated. The film runs for twenty-seven minutes.

A second film shown recently was presented by Audley Engineering Company, Ltd., and deals with the "Audco" valve pressurised lubrication system. Processes involved in the manufacture of the "Audco" valve are shown, with some of its many applications. The valves are made in sizes up to 24in and designed for controlling pressures from fine vacuum up to as high as 5000 lb per square inch. The film is a 16mm "Ektachrome" sound film and runs for twenty-six minutes.

[Reply Card No. E5344]

Pneumatically Controlled Air Supply Valve

A NEW design of valve has been introduced by the Ozonair Engineering Company, Ltd., The Esplanade, Rochester, Kent, for the control of high velocity air supplies in ventilating installations. The construction of one of these valves can be seen in the illustration above. It consists of a frame in which are mounted a series of hollow aluminium aerofoil vanes. Within each vane there is a sealed neoprene bag, known as the actuator, which is connected to a supply of pressure air through a manifold at the side of the assembly. When it is required to reduce the flow of air through the unit, pressure air is fed into the neoprene actuators which dilate to expand the vanes. When the vanes are fully expanded their profiles come into contact to shut off the flow of air with very small leakage.

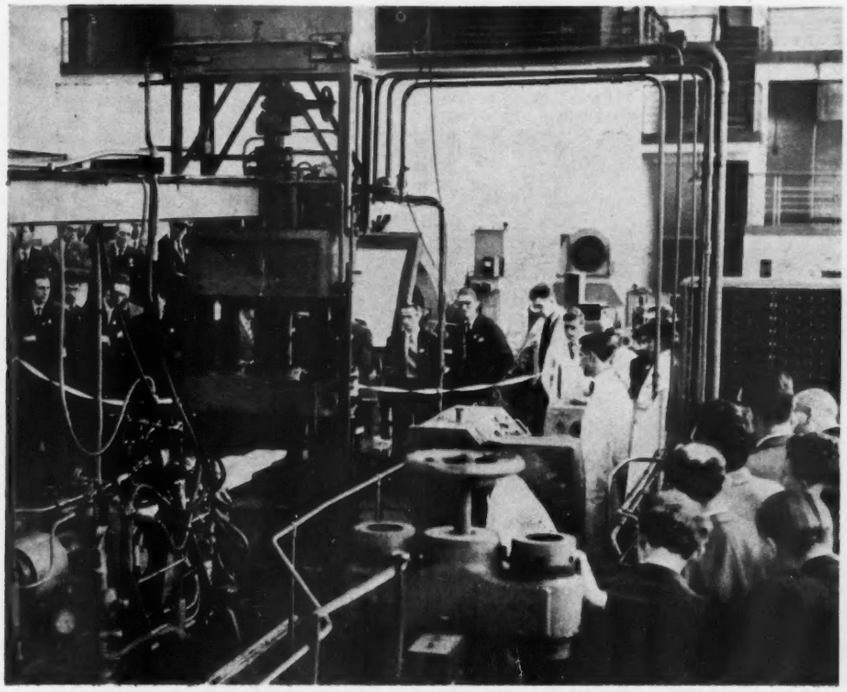


High velocity, pneumatically controlled air supply valve

These "Pneumavalves," as they are known, are made in sixteen models of from 10in by 6in to 32in by 24in and the largest size is suitable for an air flow of 9600 cubic feet per minute. For larger air flows the valves can be used in multiples with their pressure control lines connected in parallel to a controlling thermostat or pressure regulator. The pressure drop at nominal rated air capacity with these valves is stated to be only 0·20in w.g., and leakage between 1 and 3 per cent, depending upon valve size.

For dual duct applications, two of the valves are mounted in a mixing box. The hot air valve of such an installation is connected to the room thermostat and the cold air valve to the constant pressure regulator controlling the total mixed air volume to be delivered. When the thermostat operates to modulate the hot air, the pressure regulator simultaneously modulates the cold air to maintain the supply volume constant. These dual duct mixing boxes are made in nine basic sizes for air deliveries from 1500 to 9600 cubic feet per minute.

[Reply Card No. E5345]



Experimental plant engaged in forging under pre-calculated programme control

Forging With Programme Control

A COMPLETELY automatic steel forging sequence by a pre-calculated programme has been successfully demonstrated for the first time in the experimental forge of the British Iron and Steel Research Association in Sheffield. This demonstration can be seen in progress in the photograph we reproduce. The forging operation was carried out on a precision-controlled 200-ton press interlocked with a fast, remotely-controlled, manipulator capable of imparting the necessary longitudinal, rotational and lifting movements to the billet. For the operation of this press and manipulator electric controls were developed to synchronise their movements and give rapid and accurate working. Every detail of the schedule of forging operations was set up in a programme control unit which was used to control the two machines throughout the forging sequence.

The forging schedule calculated in advance was based upon a theory of the change of shape during forging, which had been worked out in the laboratory. In this schedule the upper and lower limit of the squeeze for every pass were given, the amount of manipulator feed between strokes was selected and the manipulation between passes was stored. Under the schedule the control unit signalled instructions to the press and manipulator in the appropriate sequence.

It is stated that as a consequence of this programme control of the machines a finished forging in some respects exceeded the best current industrial standards in dimensional accuracy and the work was carried out twice as fast as a good skilled forging crew would be capable of doing it.

[Reply Card No. E5351]

Marine V.H.F. Installations

THE allocation of a band of frequencies (157·45 to 160·5 Mc/s) for private radiotelephone working between ships of a fleet and their base station makes it necessary to provide these facilities without conflicting with watch-keeping on the international calling frequency. We illustrate the v.h.f. installation in the radio room of the P. & O. liner "Himalaya," which combines these services and intercommunication services within the ship in one compact layout. The equipment, supplied by Redifon, Ltd., Marine Sales Division, Broomhill Road, London, S.W.18, comprises the GR.286 twenty-five-channel f.m./a.m. radio-telephone mounted above a combined control and switching panel and line amplifier. "Himalaya" was the first of the P. & O. ships to complete an installation of this kind, which is also being provided in the other vessels of the fleet and throughout the fleets of fourteen other British shipping companies.

The two sections of the GR.286 equipment comprise an eighteen-channel f.m. section for the international frequencies (156·05–157·4 Mc/s) and a seven-channel a.m./f.m. private section. Continuous watch may be maintained on the international safety and calling channel simultaneously with a watch on any one of the private channels.

The handset seen plugged into the intercomm. panel in the illustration is of a design which may be installed remotely from the radio equipment and provides for loudspeaker watch with local volume control, and bell calling facilities. Full duplex working is provided on the double-frequency channels. Seven of the international channels are single-frequency, and for these "press-to-talk" technique is employed, the pressel switch being incorporated in the radio operator's handset. Transmitter power is 10W into the aerial. For f.m. the crystal-controlled oscillator is phase-modulated from the microphone circuit, a harmonic multiplier providing the required frequency swing and driving the push-pull amplifier.

The equipment is linked with the ship's main telephone switchboard, enabling calls with public telephone services ashore to be conducted direct from cabins or from telephone kiosks in the ship.

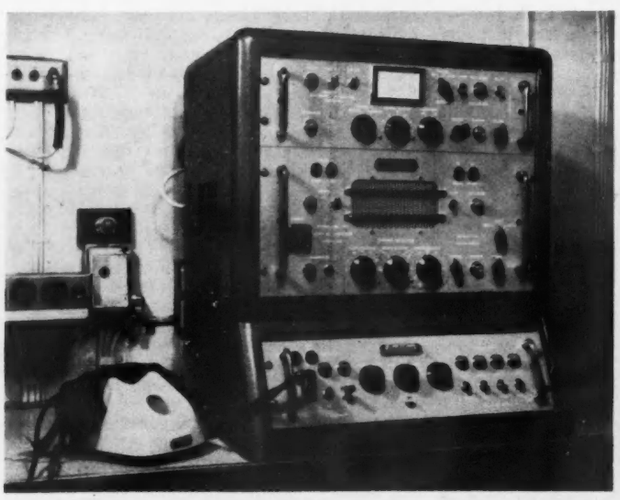
[Reply Card No. E5352]

Miniature Electromagnetic Clutch

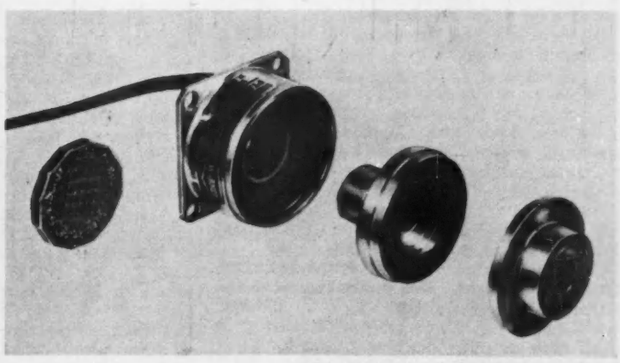
A MINIATURE electromagnetic unit, only 1¼in in diameter, made by Westool, Ltd., St. Helen's Auckland, Co. Durham, is designed to transmit a maximum static torque of 2 lb in. It is rated at 6W and has a response time of a few milliseconds. This miniature clutch, or clutch coupling, which can be used with a maximum speed of 15,000 r.p.m., is suitable for use in control mechanisms on light instrument drives, computers and servo-mechanisms.

The unit, as can be seen in the illustration below, consists of one stationary and two rotating parts. The stationary member is the field which contains the coil, and when it is energised flux flows from the field to the rotor, which attracts the armature allowing the driving member to be coupled to the driven member. The armature is mounted on a splined hub, which can be attached to either the driving or driven shaft, thus allowing the armature to move axially for automatic compensation of wear and effective release when the clutch is de-energised.

[Reply Card No. E5353]



Combined international and private communication v.h.f. transmitter-receivers and ship's intercommunication unit in the P. & O. liner "Himalaya"



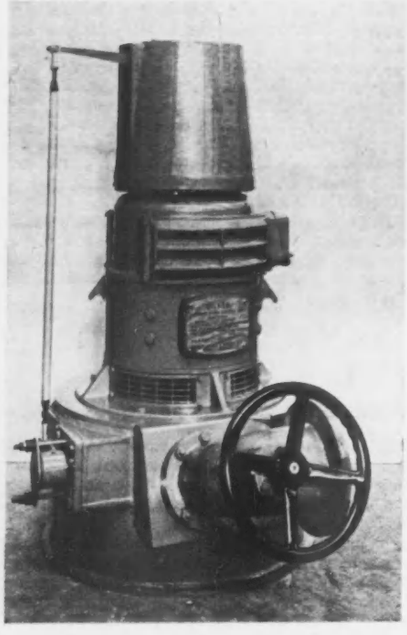
Component parts of a miniature electromagnetic clutch or clutch coupling

SHORTER REPORTS *(Continued)*

Standard Hydro-Electric Generator Sets Up to 25kW

A RANGE of small standard hydro-electric sets designed to provide a simple and reliable source of a.c. power in remote and isolated areas has been developed by Gilbert Gilkes and Gordon, Ltd., Kendal, Westmorland. These generating sets cover a range of power from 5kW to 25kW; they are suitable for heads between 90ft and 300ft (26·5m and 91·5m) and they can be supplied for any voltage up to 550V, at 50 or 60 c/s, single-phase or three-phase to suit local supply conditions.

The main emphasis is on simplicity of design and construction and a typical set, as illustrated



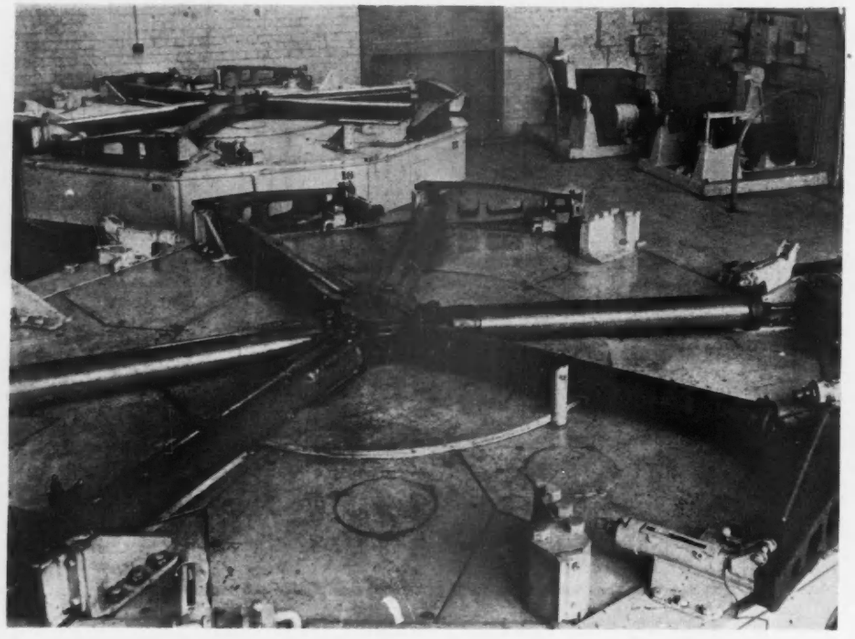
Typical standard hydro-electric unit consisting of a vertical shaft alternator mounted on a Gilkes "Turgo" impulse wheel, with speed regulation by a shaft governor operating a jet deflector

here, consists of a Gilkes "Turgo" impulse wheel overhung on the lower shaft extension of a vertical shaft alternator. Water is supplied to the turbine through a handwheel-operated spear regulator of normal design, which obviates the need for an inlet valve if the pipeline is short. Speed control is by means of a jet deflector operated by a shaft governor of new design mounted on top of the alternator.

Being a governed set, generating alternating current at standard voltage and frequency, it can be used to operate normal domestic, agricultural and small industrial equipment. The alternator is of the "Stamford" design (developed by Arthur Lyon and Co. (Engineers), Ltd., Stamford, Lincs), and has a simple static excitation and regulation system housed in the control panel. Voltage regulation is stated to be very close at all lagging power factors. The sets are designed as standard for tropical conditions and altitudes up to 10,000ft.

Only very simple foundations and turbine house are required. We understand that the maker is developing other designs for outdoor installations, for direct mechanical drives to small mills or other machinery, and for asynchronous units to operate in parallel with existing power systems.

[Reply Card No. E5361]



Fatigue testing laboratory and heavy coil spring fatigue testing machines

Coil Spring Research Laboratory

NEW laboratories for the Coil Spring Federation Research Organisation were opened in Doncaster Street, Sheffield, on Thursday, March 24, by Sir Harry Melville. This research organisation was set up by the Coil Spring Federation in 1945 and the importance of its work is indicated by the fact that only half of its total membership of 100 are spring makers —the remainder being firms in the supplier or user industries. Prior to the establishment of the laboratories most of the work of the organisation was carried out in universities and this association will continue, indeed two projects on the current research programme are at present being investigated by university departments. With the opening of the new laboratories, stated to be amongst the most comprehensive of their kind, the scope and facilities of the organisation have been considerably widened. The equipment installed will enable investigations to be carried out on springs made from the finest wires up to 2in diameter bars as well as various materials in wire and strip form.

The ground floor of the new building contains the laboratories used for heavy-fatigue testing, general mechanical testing, experimental heat treatment and electroplating. In the fatigue testing laboratory there are two 12½ h.p. machines capable of applying a dynamic load of 9 tons for fatigue testing heavy coil springs. On these machines, one of which we illustrate, up to eighteen springs may be tested at one time. Other machines used for fatigue testing springs used in internal combustion engines are capable of running at infinitely variable speeds of compression up to 4000 per minute.

The mechanical testing laboratory houses a variety of conventional machines used for determining the properties of both specimens and springs, covering the range of material diameters 0·004in–2·0in. One machine capable of developing a maximum torque of 120,000 lb-inch is now being used to investigate the effects of hardenability on the static torsional properties of large-diameter spring steel bars. For the determination of fatigue characteristics of drawn wires of diameters 0·01in–0·25in there are used high-speed rotating-beam fatigue machines, which can in one week complete up to 100 million cycles.

A study of corrosion and protection of spring materials and the effects of hydrogen embrittlement due to electroplating is being continued in a new specially fitted laboratory, having facilities for electroplating copper, zinc, tin, cadmium and nickel.

The first floor of the building is devoted to light laboratories containing small static testing machines, general scientific instruments and equipment, administrative offices, and a conference room. A materials testing laboratory on this floor contains machines for determining macro-hardness, tensile and torsional properties of wires, and load-deflection characteristics of small springs.

A comprehensive research programme which is being followed includes an investigation into the hardenability of spring steels and its influence on mechanical properties. This work is being carried out to determine the maximum permissible section required to obtain through hardening for various spring steels and the effect of percentage of martensite on the static and dynamic torsional properties of the steels. In connection with springs for use under high temperature conditions, work is being carried out to assess the relaxation properties of a variety of spring materials and to measure long-term creep effects.

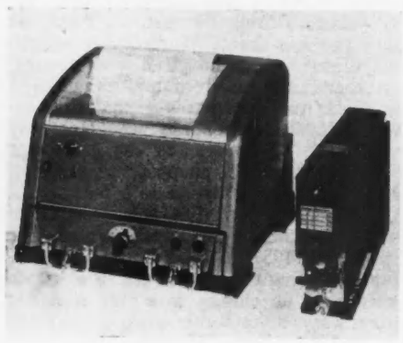
The fatigue life of heavy-duty springs is of particular importance in many applications and work has been undertaken to determine the influence that the type of material, heat treatment and surface finish has on such springs. The properties of titanium have made this metal attractive for certain applications where corrosion fatigue is a problem. For this reason research is being carried out to determine the static and fatigue properties in torsion of various titanium alloy wires in a condition of cold work or heat treatment suitable for springs. In connection with the practice of shot peening spring materials, an investigation is in progress to ascertain the variation in shot peening efficiency with different types and sizes of shot applied at different velocities and times to determine the stresses induced by these variables.

In addition to general research an appreciable amount of private investigation is carried out for member firms of the federation and, if required, for non-member companies having problems in connection with springs.

Aircraft Teleprinters for B.O.A.C.

WEATHER reports in B.O.A.C. Boeing 707 aircraft operating on the North Atlantic route will be received on the lightweight teleprinter installation illustrated. The equipment, which is being supplied by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, comprises the AD308 all-transistor radio receiver and the Creed teleprinter receiver, together with an aerial matching unit and omnidirectional loop aerial.

Growing congestion of h.f. communication channels for aeromobile services led to the suggestion some years ago that certain advisory messages, such as meteorological information, might be transmitted on a special ground-to-air link operating on a frequency chosen for optimum performance on the North Atlantic route. If such messages are radiated from a ground



Lightweight teleprinter receiver and transistorised radio receiver for installation in B.O.A.C. aircraft on North Atlantic route

station operating in the low-frequency band and received on a radio-teleprinter in the aircraft, the bandwidth required for transmission is much less than would be taken up by radiotelephony. The teleprinter will operate without attention and messages can be taken from it at intervals suited to the normal routine of the aircraft.

At present weather broadcasts providing complete coverage for the North Atlantic are being made from transmitters in Scotland and Northern Ireland. The Marconi AD308 teleprinter radio receiver seen on the right of the illustration is a fully-transistorised instrument designed to operate in services of this kind. It is capable of receiving narrow-band frequency-shift-keyed telegraph services on any one of four spot frequencies in the 90–150 kc/s band and produces a double-current output suitable for operating a standard teleprinter. For the present purpose the AD308 will be used in conjunction with the Creed lightweight teleprinter shown. Combined weight of the equipment is 45 lb.

A loop aerial is used to minimise the effects of precipitation static, and the receiver includes circuits which give omnidirectional reception from such an aerial. These are followed by two r.f. stages and a mixer, the base of the latter being fed from the second r.f. transformer and from a crystal-controlled local oscillator followed by a buffer stage. No crystal ovens are used, the local oscillator and discriminator crystals being selected so as to have almost equal drifts with temperature. Apart from considerations of weight or power consumption, this arrangement has the advantage of immediate operation whenever the receiver is switched on.

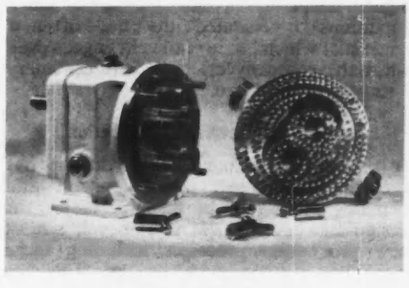
The mixer collector circuit consists of a narrow-band crystal filter, the output from which is fed to a two-stage i.f. amplifier. The second stage has two output points, one feeding the a.g.c. detector and the other feeding the two-stage limiter. A Foster-Seeley discriminator follows, with crystal across the secondary circuit, the combination of crystal and tuned circuit giving a steep characteristic. The two diode loads of the discriminator feed the demodulated signal into push-pull driver and output stages, each transistor in the latter being connected to one half of the teleprinter electromagnet winding. A centre-tap on this winding is connected to chassis via a resistor, the voltage across which is used to control the collector current of a transistor providing a bias for the output stage. In this way the output current is maintained at optimum value. Power supply, totalling 4W, is taken from the aircraft system through a plug-in sub-unit incorporating zener diode stabilisers.

The Model Seventy-Five airborne teleprinter receiver is manufactured by Creed and Co., Ltd., Telegraph House, Croydon. Its dimensions are approximately 15in by 13½in by 11in high and it weighs 35 lb. The instrument is designed to work reliably in non-level positions and in conjunction with the radio receiver provides continuous automatic recording of five-unit start-stop telegraph signals in printed page form at a speed of 60–66 words per minute. Speeds up to 100 words per minute are available when operated with appropriate terminal equipment. The paper capacity is for a 200ft roll accommodated within the cover, which is sufficient for at least ten hours' recording at 60 words per minute. Operation of the teleprinter and associated radio receiver is controlled by the five-position switch on the front of the former, which on being moved from "off" to one of the four channel-selection positions simultaneously switches on the radio receiver and sets up the teleprinter so that its motor starts automatically when the first "space" signal is received. The machine operates on a 28V d.c. supply.

[Reply Card No. E5371]

Small Rotary Pump

A ROTARY pump for handling sticky and viscous fluids in the food and chemical industries made by Stainless Steel Pumps, Ltd., Myrtle Road, Eastbourne, can be quickly and easily dismantled for cleaning by the removal of four wing nuts. All parts of the pump which come into contact with the fluid are made of stainless



Rotary pump dismantled for cleaning

steel, and our illustration shows the main components when dismantled.

The drive gearbox is isolated from the main pump housing and two splined shafts from it project through the pump back plate into the rotor chambers recessed in the head casing. A standard "O" ring is said to provide a seal between the head casing and the back plate. By the mounting of the drive in a separate casing contamination of liquids being handled is avoided, and when the pump is working there is no surface contact between its moving parts.

These pumps are made in five sizes to handle from 50 to 10,000 gallons an hour against a maximum head of 75 lb per square inch, depending upon the viscosity of the fluid. They are self-priming and the makers state that a pump can run dry for up to half an hour. The rotors are normally fitted with packed glands, but "Flexibox" mechanical gland seals can be supplied if required.

[Reply Card No. E5372]

Technical Reports on Structural Timber

FOUR technical reports on various aspects of the use of timber as a structural material have recently been published by The Timber Development Association. The first of these reports, which is the work of one of the Association's committees, is of very general interest since it lays down production standards for glued laminated timbers which are to be used structurally. The subject is treated quite comprehensively, covering, for instance, the choice of glues, choice of species for lamination, and extracts from comparable Canadian standards. The report is called *Production Standards for Glued Laminated Timbers*. The second report is also of wide practical interest; its title is *Fabrication Manual for Connecting Assemblies*, and it also is the work of a T.D.A. committee. It covers structural units jointed by nails, screws, bolts or timber connections.

An interesting discussion of the advantages of non-destructive testing for timber, where successive test specimens may not be precisely identical, or where the progress of decay due to insects or fungus in a specimen is being followed, is given by the author, Mr. I. D. G. Lee, in the report *Non-Destructive Testing of Wood by Vibration Methods*. Sonic and ultrasonic methods of testing are reviewed, and subjects such as examining an old roof structure and finding breaks in the glue lines of laminated components are explained. Lastly, a theoretical analysis of a structural type used in timber is given by Mr. H. Tottenham in the report *The Effective Width of Plywood Flanges in Stressed Skin Construction*. A series of joists and stressed skin plywood panels can be considered structurally as a series of I-beams in which the joists are the webs, and the plywood the flanges. Design is based on the concept of "effective width" of the flanges, and an example is given. Each of these four reports costs 3s. 6d.

Split Watersealing Device for Joints in Concrete

JOINTS in concrete are commonly made watertight by positioning seals made of copper or rubber or some such material, such that half of the seal is cast into the monolith on each side of the joint. One such seal is a strip of rubber shaped like a dumb-bell in section, the joint in the concrete occurring transversely at the centre of the "dumb-bell." An improvement of this joint is now being made by Tretol-Servicised, Ltd., in which the seal is split, the split passing, in section, through one end to the centre of the dumb-bell shape. When concreting, the split portions are flattened against the inside of the shuttering, so that the joint assumes a T-shape, the unsplit half being cast into the concrete in the normal way. Thus the seal can be positioned without any complication to the shuttering; when the shutter is struck, the split pieces are pulled out and stapled together to form the second half of the seal, ready to be cast into the new concrete.

[Reply Card No. E5374]

Launches and Trial Trips

FABIOLA, oil tanker; built by the Ateliers et Chantiers de France for the Compagnie Auxiliaire de Navegation; length between perpendiculars 723ft 1½in, breadth moulded 100ft 5in, depth 51ft 9½in, draught 38ft 0½in, deadweight 47,350 tons, speed 17 knots; two Mark 9, 74 V.T.B.F. 160 Burmeister and Wain diesel engines coupled to one shaft, 22,500 h.p. at 115 r.p.m. Trial, January 8.

NORTH QUEEN, bulk carrier; built by the Chantiers Réunis Loire-Normandie for Panatlantica Compania Naviera (Panama), length between perpendiculars 441ft 11in, breadth moulded 59ft 7in, depth to shelter deck 39ft 6in, draught 26ft 6in (open shelter), 30ft (closed shelter), speed 14 knots; Sulzer Mark 8 S.D. 72 diesel engine, 5600 h.p. Trial, January 22.

VULLAIN, ore carrier; built by the Forges et Chantiers de la Gironde for Soflumar; length between perpendiculars 507ft 8in, breadth moulded 68ft 10in, depth 43ft 7in, draught 29ft 6in, deadweight 16,700 tons, displacement 23,020 tons; speed 14·3 knots: Creusot-Schneider-B and W, 6·74 V.T.B.F. 160, six-cylinder diesel engine 7500 h.p. at 115 r.p.m. Trial, January.

INDUSTRIAL NEWS

Industrial Design in Practice

A conference arranged by the Council of Industrial Design was held in Manchester on Thursday of last week. Although the specific theme for discussion was " Industrial Design and Textile Machinery," there were several matters of a more general nature raised during the proceedings. Mr. W. L. Mather, for example, in a paper entitled " Putting Industrial Design into Practice," suggested that the " emerging nations " to-day laid great stress on novelty and appearance. Modern appearance and gay colours, he said, were part of the new standard of living which those nations were determined to enjoy.

The British, Mr. Mather continued, had deep faith in tradition, but the certainty and security which it provided could destroy initiative and adventure. He felt that as a great exporting nation, this country must be alive to the new standards and, whilst observing its traditions of quality and integrity, it must design machines suitable for the emerging countries. Britain, Mr. Mather emphasised, was the workshop of the world, setting the standards which others followed ; it was seldom necessary to look far afield for new ideas. Yet to-day, he added, there was hardly a country which was not producing ideas of merit or setting new standards and, while Britain might still be the fountainhead of invention, she must also observe, digest and improve upon the new ideas and rising standards of others.

Work of Engineering Construction

The Ministry of Labour states that regulations extending the definition of the expression " work of engineering construction " in Section 152 of the Factories Act, 1937, were laid before Parliament last week. These regulations will come into operation on May 15. Under the regulations works which will now also be included within the definition are the construction, structural alteration or repair (including re-pointing or repainting), or the demolition of any steel or reinforced concrete structure other than a building, any road, airfield, sea defence works or river works, and any other civil or constructional engineering works of a similar nature to any of these works. The definition will not, however, apply to the works if they are carried on in a factory as defined in the 1937 Act, or on premises to which that Act applies, or on a railway or tramway.

The effect of the regulations is that from May 15 the requirements of the Factories Acts about sanitary conveniences and about notifying sites of operations, accidents and industrial diseases among others will apply to these classes of work. The new safety regulations for construction work, which the Minister proposes to make will also apply to them.

Young People in Industry

The Ministry of Education has prepared a coloured poster illustrating the range of opportunities open to school-leavers to train for industry and commerce. The poster, which is entitled " Your Future in Industry," is being sent to all local education authorities. A circular which accompanies the poster points out that since the Government launched its plan for expanding technical education, four years ago, the technical colleges have produced about half of the 50,000 scientists and engineers who have obtained degrees and professional qualifications. In the same period the colleges have helped to train over 200,000 craftsmen and technicians in industry. Full-time sandwich courses, the Ministry says, are now attracting about four times the number of students that they did four years ago.

Copies of the poster may be obtained free from the Ministry of Education, Curzon Street, London, W.1.

Nickel Alloys in Industry

An exhibition is being held this week at 45, Park Lane, London, W.1, by Henry Wiggin and Co., Ltd., to demonstrate the many uses of nickel alloys in industry. The object of the exhibition is to assist engineers and designers to make the best use of the company's high-nickel alloys. These alloys fall mainly into four groups, namely, corrosion-resisting, heat-resisting, electrical resistance and materials with special physical properties. The exhibition includes demonstrations of these properties and indicates the correct method of fabrication of the alloys.

At the opening of the exhibition on Monday, Mr. R. E. Ansell, sales director, recalled that the company had been in continuous operation for just about 125 years. The march of progress in the field of engineering and technological processing, he commented, was very rapid in the direction of higher temperatures and pressures. Such conditions necessitated the use of new materials which were not envisaged even when the company celebrated its centenary twenty-five years ago.

Gas Council's Development Section

The Gas Council says that it has decided to establish a development and planning section to be responsible for the design and development to full scale size of new production processes including those discovered at its research stations. This step is being taken because the development and expansion of the gas industry need the introduction of new sources of raw material and new methods of processing coal. These new methods, the Council believes, must be operated on a large scale if they are to produce gas economically. The new section will also be responsible for preparing plans on a national basis for an integrated supply system which is the logical development of the policies of integration and concentration of production adopted by area gas boards. Furthermore, the development and planning section will also ensure continuous contact between those responsible for research in the industry, and those responsible for commercial production.

Ironfoundries

Speaking at the recent annual meeting of the National and Midland Ironfounders Association, the chairman, Mr. W. James, referred to the steady improvement in working conditions in ironfoundries in this country. Nevertheless, he said, there were still quite a number which did not reach what should be regarded as a minimum standard. He also spoke about the " powerful and effective influences " at work within the ironfounding industry, saying that what was originally looked upon as a craft occupation had now developed into one of the most scientifically controlled industries.

Thus, Mr. James continued, there had been brought about in the industry a concentration somewhat on the lines proposed, but subsequently abandoned, during the war years. During the last ten years, he stated, no less than 370 ironfoundries had been closed and although it was possible that some listed as ironfoundries included malleable ironfoundries, the majority, no doubt, related to foundries producing grey iron castings. The rate of closure, Mr. James commented, was also interesting. Between 1950 and 1953, seventy-five foundries ceased to operate, between 1954 and 1956, there were 157 foundries that ceased, and in the three years 1957 to 1959 the number of foundries going out of production was 166. The reasons for closing, he added, were not always easy to establish but probably the principal reason was the capital expenditure required to bring the foundries up to date. Another reason might well have been the unprofitable nature of the foundry industry generally especially during the somewhat depressing trade conditions of the past few years.

But, Mr. James pointed out, it would be wrong to draw the conclusion that the production of iron castings in the future would be concentrated within the limits of a few very large concerns. It did mean, however, that there was being created what might be described as a minimim size unit varying in some way according to the kind of products made, but large enough to ensure the highest possible standards in working conditions and capable of benefiting from all the technological advances which had been and were being made.

Manufacturing Industry's Stocks

Information collected by the Board of Trade indicates that, in the final quarter of last year, there was a strong upward trend in stocks held by this country's manufacturing industries, thus suggesting that stock building was an important factor in the rise in production. The total value of manufacturers' stocks and work in progress is estimated to have risen by about £85,000,000 (2 per cent) during the fourth quarter of 1959. This is the largest quarterly increase in the value of stocks since the first quarter of 1957. What is more significant, however, the Board of Trade says, is that it was the largest increase in the fourth quarter of the year since the collection of this kind of information started at the beginning of 1955. Rather less than half of the £85,000,000 increase in total stocks was accounted for by work in progress ; materials and fuel, and finished goods each accounted for about one-quarter. During 1959 as a whole, manufacturers' stocks are estimated by the Board of Trade to have increased by approximately £120 million, virtually all in the second half of the year, compared with " little change " during 1958.

PERSONAL AND BUSINESS

Appointments

MR. J. H. THORP has been appointed sales manager of Semiconductors, Ltd.

SIR CECIL WEIR has been appointed chairman of the British Standards Institution's export panel.

MR. GORDON LILEY has been appointed to the board of directors of British Lead Mills, Ltd.

MR. K. F. GOODENOUGH has been appointed a director of Goodenough Pumps, Ltd., and associated companies.

MR. WILLIAM GERARD BRYCE, A.M.I.Mech.E., has been appointed general manager of Heyes and Co., Ltd., with effect from April 1.

MR. R. S. H. SHEPARD and Mr. L. B. Devins have been appointed joint managing directors of The Sheffield Wire Rope Company, Ltd.

THE INTERNATIONAL ATOMIC ENERGY AGENCY has appointed Professor Carlo Salvetti as director of the Agency's division of research and laboratories.

MR. P. D. OSBORN, A.M.I.E.E., has joined the Electric Construction Company, Ltd., as sales manager for London and the Southern Counties.

THE BRITISH PLASTICS FEDERATION has announced that Mr. David Radford has been elected chairman in succession to Mr. N. B. Punfield. The new vice-chairman is Mr. Finlay Walls.

THE MINISTRY OF PENSIONS AND NATIONAL INSURANCE has announced the appointment of Mr. S. Alan S. Malkin and Mr. William Taylor to be members of the Industrial Injuries Advisory Council.

MR. W. N. COLLINS, assistant managing director of F. Perkins, Ltd., has been elected chairman of the Society of Motor Manufacturers and Traders' marine section, in succession to Lieut.-Commander J. W. Thornycroft.

DOWTY NUCLEONICS, Ltd., announces that Mr. T. D. H. Andrews, director and general manager, has been appointed managing director. Mr. D. G. A. Thomas, chief engineer, has been appointed a director of the company.

BRUCE PEEBLES AND CO., Ltd., announces that Mr. D. McDonald, A.M.I.E.E., chief engineer, has been elected to the board of directors. Mr. C. Phillips, general works manager, has been appointed divisional director, works.

EASTERN REGION, BRITISH RAILWAYS, has announced the appointment of Mr. H. R. Gomersall, formerly planning officer (reconstruction), general manager's office, Liverpool Street, as regional planning officer in the same office.

CROMPTON PARKINSON, Ltd., announces that Mr. Brian Jubb, A.M.I.Mech.E., A.M.I.E.E., has been appointed sales manager, Guiseley a.c. motors in the industrial motors and lighting division, and Mr. C. E. Hucker has become sales manager, fractional horsepower motors.

THE MINISTRY OF POWER has announced the appointment of Sir Thomas Williamson and Mr. Harry Douglass to be part-time members of the Iron and Steel Board with effect from June 1, in place of Sir Andrew Naesmith and Mr. J. Owen, whose appointments expire on May 31.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION announces that at the first meeting of the Council for the session 1960-61, the following re-appointments were made : president, Sir Leslie Gamage ; chairman, Mr. W. K. G. Allen ; vice-chairman, Mr. A. M. Browne.

MR. J. R. COTTERILL, M.I.Mech.E., M.I.E.E., has been appointed manager of the outside services department at the Witton Works of The General Electric Company, Ltd. This is a new department formed to co-ordinate erection, commissioning, and post-commissioning service of electrical plant.

DR. M. E. HAINE, M.I.E.E., has been appointed director of A.E.I. Harlow research laboratory. He succeeds Dr. G. W. Sutton, M.I.E.E., who has retired, but who is continuing in a consultative capacity until May. Harlow, and its associated Blackheath research laboratory, serve four A.E.I. product divisions that are managed by Associated Electrical Industries (Woolwich), Ltd. They are : A.E.I. cable division ; A.E.I. construction (cables and lines) division ; A.E.I. radio and electronic components division, and A.E.I. telecommunications division.

THE FAIREY COMPANY, Ltd., announces the appointment of Mr. L. R. E. Appleton as managing director of Fairey Engineering, Ltd., and Mr. P. J. Duncton, who is already a director of Fairey Engineering, as general manager, Heston. Mr. H. G. Gregory remains director and general manager of Fairey Engineering's Stockport factory.

RICHARD COSTAIN, Ltd., announces the following new appointments from among the existing executive staff : Mr. B. K. Clancy, managing director, Richard Costain (Civil Engineering), Ltd.; Mr. P. Lederer, managing director, Richard Costain (Construction), Ltd.; Mr. J. B. Parrett, chairman, and Mr. C. Hammersley, managing director, Westminster Plant Company, Ltd.; Mr. J. F. Robinson and Mr. J. P. Sowden, joint managing directors, Richard Costain (Associates), Ltd.; Mr. P. Loveday, managing director, Richard Costain (Projects), Ltd.; Mr. E. G. Lewis, managing director, Costain Property Investments, Ltd.

S. SMITH AND SONS (ENGLAND), Ltd., announces that, following the appointment recently of a co-ordinating board, further reorganisation has taken place, with particular reference to the aviation side of the business. Arising out of this, Mr. G. B. G. Potter, M.I.Mech.E., whilst retaining the managing directorship of the divisions, will further concern himself with the direction of the collective research and engineering facilities. Mr. K. Fearnside, A.M.I.E.E., of Smiths Aircraft Instruments, Ltd., has been made directly responsible to Mr. Potter for Smiths Aircraft Instruments, Ltd.'s, research and engineering, and has been appointed director of research and engineering of that company. Mr. Roberts remains technical director of Smiths Aircraft Instruments, Ltd., and as such will assist Mr. Fearnside in his new appointment.

Business Announcements

MR. MILES B. REID has resigned from the board of Mobil Oil Company, Ltd.

FIRTH CLEVELAND PUMPS, Ltd., has moved to a new factory at Earl Shilton, near Markfield, Leicester (telephone, Earl Shilton 2071).

ENGLEHARD INDUSTRIES, Ltd., Hanovia Lamps Division, Slough, has taken over the sole agency in the United Kingdom for the Heraeus Quarzschmelze G.m.b.H., Hanau, West Germany.

HUSBAND AND CO., Consulting Engineers, have changed their London office address from 70, Victoria Street, to 58, Victoria Street, London, S.W.1 (telephone, Victoria 6418 and 7731).

G. D. PETERS AND CO., Ltd., Slough, announces that sales of its electrodes will in future be handled by Weldcraft, Ltd. G. D. Peters will continue to manufacture the electrodes and trade names will remain unchanged.

THE GEORGE COHEN 600 GROUP, Ltd., announces that the Selson Machine Tool Company, Ltd., has been appointed sole agent in the United Kingdom for the milling machines manufactured in France by Ateliers Georges Vernier.

THE ASSOCIATION OF INDUSTRIAL MACHINERY MERCHANTS states that its address is now 37, Soho Square, London, W.1 (telephone, Gerrard 6588). Mr. T. Garbett, of Farrow and Sons, Ltd., Spalding, Lincs, has been appointed the public relations officer to the Association.

PIONEER OILSEALING AND MOULDING COMPANY, Ltd., Colne, Lancashire, announces that the company has purchased Lower Clough Mill at Barrowford, Nelson, East Lancashire, and will enter into occupation later this year. The new premises provide 130,000 square feet of floor space.

DOWTY ROTOL, Ltd., announces that the reorganisation of its engineering department has now been completed. The new arrangement, which becomes effective on April 1, is as follows : Mr. L. G. Fairhurst will be the technical director for the company. Under him will be the Arle Court Design Department headed by Mr. A. A. J. Willitt as chief engineer and dealing with the traditional Dowty products, and the Staverton Design Department under Mr. E. Danvers as chief engineer and dealing with the traditional Rotol products. The former design activities of British Messier, therefore, will be absorbed entirely within the Arle Court Design Department.

WINSTON ELECTRONICS, Ltd., Shepperton, Middlesex, has become a wholly-owned subsidiary of The Dynamics Corporation of America, New York, U.S.A. Mr. F. Winston Reynolds will continue as the chairman and managing director, Mr. Roger Laurence, director of research and technical director, and Mr. Joseph Samuels as works director, under long-term contracts. Mr. T. Anderson leaves the board.

THOS. W. WARD, Ltd., Albion Works, Sheffield, has acquired the entire share capital of Anchor Insulating Company, Ltd., Thermal Works, Woolwich Industrial Estate, London, S.E.18. Messrs. F. W. Robinson, S. J. Dyal and W. S. Isherwood, directors of Dick's Asbestos and Insulating Company, Ltd., a member company of the Ward Group, have joined the board of directors of Anchor Insulating Company, Ltd., and Mr. Robinson has been appointed chairman, and Mr. Isherwood, general manager. Mr. R. A. Fishlock remains on the board of Anchor Insulating Company, Ltd., and will be responsible for sales direction.

Contracts

SIMON-CARVES, Ltd., has received from the East India Distilleries and Sugar Factories, Ltd., a contract to build a complete new factory at Ennore, near Madras, to make approximately 51,000 tons annually of compound fertilisers based on ammonium phosphate. The total cost is expected to be in the region of £3,000,000. In addition to the compound fertiliser plant, the factory will include plants for the production of synthetic ammonia, sulphuric acid and phosphoric acid, together with equipment for handling incoming raw materials and outgoing finished products.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has received orders for traction and other equipment valued at approximately £2,750,000 as principal sub-contractor for rolling stock to be built for the South African Railways by the Union Carriage and Wagon Company (Proprietary), Ltd., of Nigel, Transvaal. The electrical equipment, scheduled for delivery in 1961, will consist of traction motors, control gear and lighting and heating appliances. It will be identical in many ways with motor-coach equipment previously supplied by A.E.I. to the South African Railways for suburban and inter-urban services on the Reef and Cape Western sections of the system, and is designed to run in multiple with it. Most of the equipment will be manufactured at the Trafford Park and Sheffield works, but the Hereford factory of the company's Lamps and Lighting Division will supply the lighting equipment.

JOHN LAING AND SON (CANADA), Ltd., has been awarded two contracts to the total value of approximately 6,000,000 dollars by the Government of British Columbia, Department of Highways, for the construction of twenty-five reinforced concrete piers and abutments for the Port Mann Bridge across the Fraser River, and a 3½ mile section of the new Trans-Canada Highway, west of Burnaby Lake, British Columbia. The former contract includes an order for steel pipe piles and steel sheet piles to the value of some 570,000 dollars, which has been placed with the South Durham Steel and Iron Company, Ltd. The latter contract comprises 3¼ miles of four-lane highway. Part of the route crosses areas of thick peat deposits and sawdust lightweight filling (to the extent of 200,000 cubic yards) and sand drains will be used in its construction. Also included in the contract are the earthworks for three large interchanges.

ASHMORE, BENSON, PEASE AND CO. AFRICA (PTY.), Ltd., of Johannesburg, and P. G. ENGINEERING, Ltd., of Stockton-on-Tees, two member companies of the Power-Gas Group, are to carry out an order valued at over £1,000,000 for the Rhodesia Broken Hill Development Co., Ltd. The order is for a zinc and lead I.V. furnace, which will be installed at Broken Hill, Northern Rhodesia, and the contract includes the engineering, procurement and construction of the whole of the plant within the furnace area covering foundations, plant and equipment. Process design is being supplied by Imperial Smelting Processes, Ltd., and on completion at the end of 1961 the plant will be one of the first four operating in the world. The new contract will be engineered in Salisbury in close collaboration with the client's consulting engineers, the Anglo American Corporation of South Africa, Ltd.

CONTINENTAL AFFAIRS

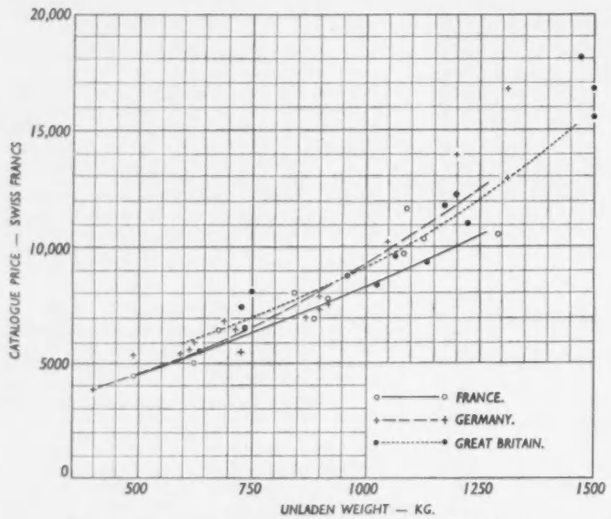
by Our Continental Editor

Geneva Motor Show

No. I

THE thirtieth Salon International de l'Automobile commenced at Geneva on March 10, remaining open every day (up to 11 p.m. on two occasions) until March 20. This exhibition is, as is well known, international in fact as well as in name, and in the number of exhibitors Switzerland itself was outnumbered by Germany, there being 245 German exhibitors out of a total of 996. This, however, is not inappropriate, since Germany is the source of well over half of the vehicles imported into Switzerland in every class except one, i.e. scooters, in which Italy provided 8862 out of last year's total of 9489 (Germany 393, Austria 206, Great Britain 21). This state of affairs, the domination of the market by one exporter, does not appear to be artificially created : for instance, both this country and the United States of America displayed more makes of cars than Germany. As far as Great Britain was concerned, however, representation was slight other than for cars, the exhibitors being usually the local representative for the British manufacturer.

A reasonable selection of English cars were to be seen, but with many exceptions such as the Ford "Popular" and all Standard models other than the "Vanguard." Thus, for cars only, it is feasible to make a study of the comparative prices of the products of different countries. The chart reproduced here shows such a comparison : on it are plotted only cars in large-scale production, and in each case the least expensive version of each car is used. The principal conclusion to be drawn from this plot is that the costs of producing cars for the Swiss market are not greatly different for the three principal European car manufacturing countries, so that the general belief that cars compete on their merits in Switzerland is confirmed. It does not appear unreasonable, however, to assign some significance to what deviation does appear between the lines showing the average (not weighted for volume of production) for the individual countries. It is not surprising to see that the German line extends to smaller cars than the others, and correspondingly that for cars below 750 kg, among which, in Great Britain, the B.M.C. ADO 15 has no competition, the German products are more favourably priced. The opposite trend to be seen at the heavy end of the scale is the natural consequence of the relatively highly developed state of the German light cars, implying that the heavy cars are luxurious and absolutely expensive models. These two curves may, in truth, deviate even less than appears because, as mentioned above, some important cars were not catalogued : thus, the 1172 c.c. Ford was plotted in the form of the Taunus 12M but not as built at Dagenham.



Comparative prices of mass-production motor-cars in Switzerland

The line for French cars is distinctly different, to such an extent that only two British products lie below it, but, unfortunately, it is based on relatively few points. It extends into the light-weight zone solely by virtue of the Citroen 2 c.v., and would be notably shorter and steeper but for the presence of the Renault "Frégate."

The stands in the show reflected the earnest effort being made to sell the products. Many of the special displays were most elaborate and expensive while, at the other extreme, it was almost invariable for doors, bonnets and boot lids to be left unlocked and for the visitors to inquire within. Part-sectioned engines and suspensions were prominent on the stands featuring the more advanced designs of cars, while among the very few passenger car chassis to be seen were the essentially similar Skoda and Triumph—the latter being the subject of repeated demonstrations of assembly from chassis form to complete car in five minutes by a team of four apprentices. One unusually significant presentation was used on the Renault stand, where three "Dauphine" cars with "Aerostable" suspension were going round and round on a circle of pavé : visitors were invited to sample the ride over the rough surface, even as on a fair-ground roundabout. A distinctive feature of the Ford stand was that, in a hall scattered with gaily-coloured cars, its stand was covered with models from the United States, Great Britain and Germany, all with their axes parallel, all with their lights on, and all finished in the same colour, a very pale grey. This display served to emphasise how deeply different the designs are, only the Taunus retaining the characteristic of extinguishing the side lights when the double-dipping head lights come on.

The confinement of British participation in the exhibition to passenger cars was accentuated by the appearance not only of new models but of a new make of car. The Gordon Automobile Company, Ltd., 228, Bath Road, Slough, Bucks, displayed its gran turismo close-coupled four-seater. This car is the product of the technical staff responsible for the erstwhile Peerless gran turismo, and has certain notable similarities to the previous car—for instance, the steel tube primary structure and the de Dion final drive. It reflects, however, the realisation that a touring, as distinct from a sporting, car cannot employ a small engine and impose upon the driver the selection of manifold ratio changes : the new car has a Chevrolet "Corvette" V-8 of 4637 c.c., with quoted outputs up to 360 b.h.p.

The Gordon, an English car with an Italian body and an American power unit : its headlamp equipment was unique in the show

Three-cylinder, two-stroke Auto-Union engine in a Formula Junior car : behind the engine is the header tank. Notice the extremely long coil springs of the rear suspension

in competition form, and either a four-speed manual gearbox or a " Powerglide " transmission. The suspension is also more ambitious, half-elliptic springs at the rear having yielded to coil springs all round, and the rear axle is located by a Watts linkage. One important detail in which the Gordon contrasts radically with established British practice is the incorporation of separate hydraulic circuits for front and rear (drum) brakes. The body is made by Bertone. In one respect the Gordon differed from every other vehicle, regardless of nationality, exhibited : it is the only private car to have adopted the 5¾in Lucas lights introduced at Earls Court the year before last, and whereas all the Continental lamps have replaceable light sources, all the United States vehicles (including the British-made " Metropolitan ") have sealed elements in which the lens and reflector envelop the filament. The car exhibited was the prototype, only recently completed, but production is planned to commence this summer : it is expected that the great majority of the cars will be exported, those destined for dollar areas having their final engines fitted in the country of destination.

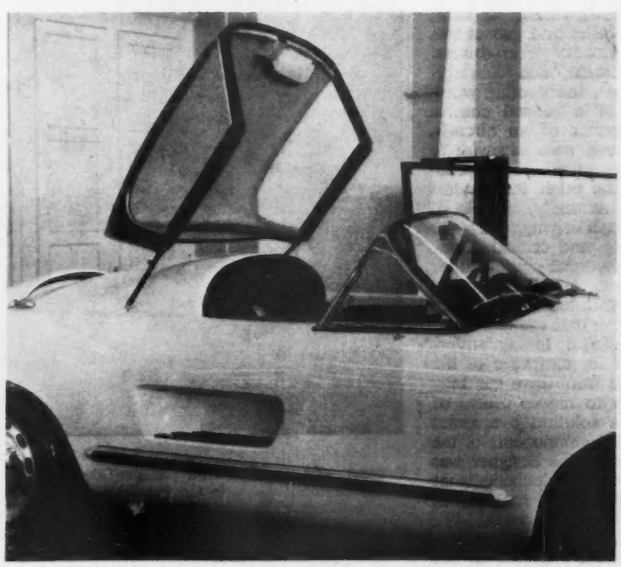
A new model making its first appearance was the Triumph " Herald " convertible. The design of the " Herald, " it will be recalled, allows the construction of the roof to be altered almost independently of the basic structure : the new version has a folding hood and frame which disappears under a cover held by press fasteners and can be erected by the occupants without getting out of the car. It is, however, necessary to get out of the car to change from the main to the reserve supply of fuel, since, as on the coupé, there is a fixed partition in front of the luggage boot. The convertible has a bench seat with a fixed, vertical squab in the back.

Another car that was unfamiliar to British visitors was to be seen on the Austin-Healey stand, in the shape of a " Sprite " with a locally-produced plastics bonnet : instead of the headlamps protruding through the profile, they were incorporated in the front of the fairings over the wheels, rather as on the six-cylinder model. Apart from the æsthetic improvement, a reduction in weight has been effected, which is particularly valuable since the nose lifts backward.

One new car was the product of a Swiss maker, the Garage Monteverdi, Basle. This was a racing car to Formula Junior (illustrated herewith). As on a minority of British cars for this formula, it is based on the Auto-Union (D.K.W.) " 1000 " three-cylinder two-stroke, bored out from 74mm to 78¼mm × 76mm for a swept volume of 1095 c.c. ; the engine has Mantzel modifications to the block and a claimed output of 100 b.h.p. (conditions not specified) at 6700 r.p.m. compared to the usual 50 b.h.p. S.A.E. Other than in its engine, the car departs sharply from English practice ; a Volkswagon gearbox with an all-synchromesh Porsche train is fitted driving Porsche hubs located by a parallelogram linkage instead of a trailing arm. The 15in Porsche wheels are very large by English standards, and the 4ft 4in front track dictated by the trailing link torsion bar suspension also appears extreme. An interesting detail is that, since the body is a narrow single-seater, the telescopic dampers cannot pick up from the trailing links themselves, and lever arms are fitted at the inboard ends of the pivots to actuate them, but the installation is such that the dampers elongate on bump and shorten on rebound. The simple space-frame has the hot tube to the top of the radiator welded to it, but the return pipe is outside and underneath the body. The panel-work is in polyester-bonded glass fibre. The gear ratios are evenly spaced but wide, peak power corresponding to 71 m.p.h. in second, 103 m.p.h. in third, and 140 m.p.h. in top.

Another car of high performance but based largely on VW components was the Entzmann. This is a supercharged roadster in which great attention has been paid to the safety of the occupants. There are no doors, entry being over the low cockpit sides, and the seats are provided with lap straps. The driver, of course, has the wheel in front of him, but in front of the passenger there is a large padded protuberance on the resilient coaming to avoid his hurting his head when thrown forward. The curved windscreen is not only fixed but built into a very strong structure to survive the car's rolling over. When a hard top is desired, it opens about a transverse axis behind the seats. The body (illustrated) is not a low-drag shape, but is claimed to be designed to avoid disturbing effects in manœuvres.

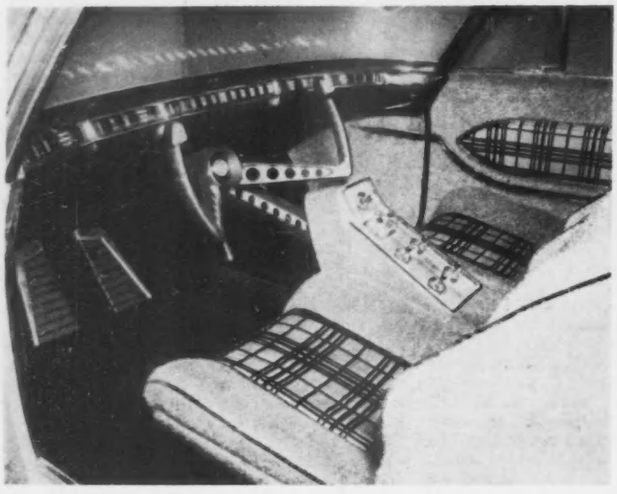
A coupé of unusual construction was displayed by Pinin Farina. This was a hard-top convertible



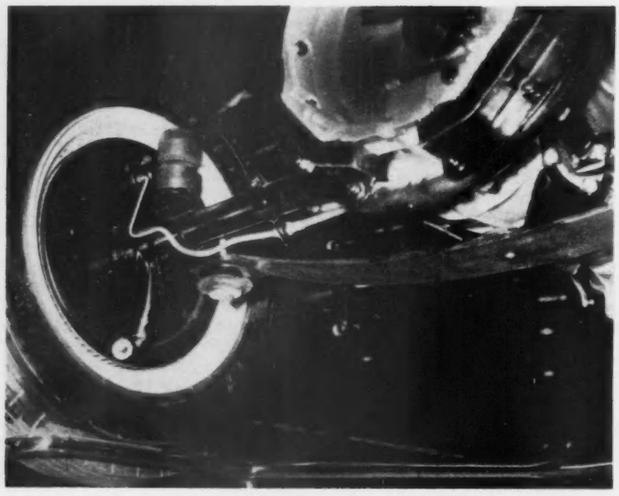
(Left) The Entzmann, a special-bodied supercharged Volkswagen, is designed to afford the occupants generous protection in case of accidents. (Right) This Farina body has roof panels that retract to lie under the rear window

CONTINENTAL AFFAIRS *(Continued)*

The "Selene" presents a radical solution to the intrusion of the undriven wheels into the cabin



(Left) Driver's compartment of the "Selene."



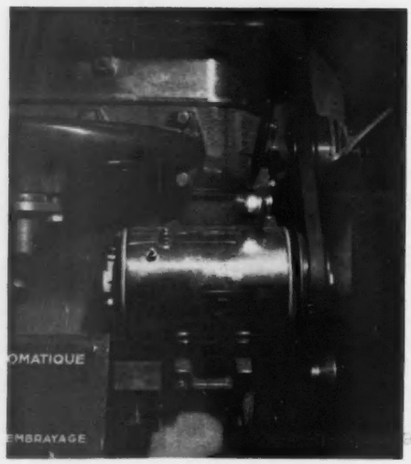
(Right) The rear suspension of the latest model Porsche incorporates a transverse leaf spring tapering steplessly in thickness

to a coupé de ville, using transparent plastics panels so that the rear aspect is not darkened when the cockpit is open. The particular car displayed and illustrated, an Alfa Romeo, did not afford a good example of this highly functional design, since in order to give access to the luggage boot the rear window was swept down so sharply as to give a kinked profile, and consequently the occupant's view to the rear in the open regime was through two non-parallel panels at an acute angle to the line of sight, and so no rear view mirrors were fitted. This principle, however, could obviously be exploited to attain the extremely difficult ideal of a streamlined convertible. The example illustrated had removable side screens instead of, as on a large proportion of the exhibits, winding windows shutting directly against the body, with no frames. Another Farina body, on a Cadillac, was of a similar shape, the cabin top being itself smoothly contoured but not blended into the body proper, but with the entire roof formed from a single transparent panel merging flush with the cant rails; in this case provision was made to shade the occupants from the sun by fitting four narrow (fore-and-aft) blinds which stowed one above the other at the extreme front of the roof and could be extended backwards along rails, rather like the roof panels of the Alfa, by power under the driver's control.

Another coachbuilder's exhibit of interest was a mock-up by Ghia S.p.A. of a possible body for a future high-performance car. Instead of the car being wide enough for three abreast, six seats were arranged rather as in a small aeroplane, the four at the rear facing in pairs; a table with recesses for bottles and glasses was provided in this compartment. The drivers' cockpit was highly functional, and arranged for control from either seat, the steering wheel swinging to either side of a central control console, again in the manner of an aircraft. The instrument presentations were edgewise to minimise the depth of the panel, the speedometer being central and the other instruments duplicated. There were, naturally, a pair of similar pedals in front of each driving seat. The "Selene" attracted serious and critical attention, being compared by a local commentator to the Stout "Scarab," even though that was a complete car of demonstrated practicality. Certainly it is easy to believe that the rear-drive car on the lines conventional to-day suffers unduly from the demands for clearance of the steerable wheels, while the front-drive car may have to sacrifice leg-room to reduce centre of gravity travel. The Ghia solution overcomes these difficulties, the variable components of the load being ideally situated. The designer was probably inspired by a reasonable belief that engine specific weights will improve radically in the near future.

Various more technical developments were also to be seen. We illustrate a display of the Peugeot 403 engine with a Jaeger clutch in the fan drive, controlled by a temperature-sensing switch which starts the fan at 84 deg. Cent. and stops it at 75 deg. Cent. This clutch, which is energised through a brush and slip-ring, is basically the same design as that offered by Smiths Motor Accessory Division. It is clear that even an on/off control of the fan is highly desirable, not merely to save power, to reduce noise, and also to improve the engine environment, but also because the forced induction of air through a cold radiator is creating conditions favourable to carburetter icing.

Other detail exhibits to be seen were an "exploded" B.M.C. ADO 15 power unit, showing the complex gear shift with its own lubrication points, and the rear suspension of the new Super 90 Porsche, the most powerful model with a push-rod engine. To give a degree of independence between spring stiffness in heave and in roll, the torsion springs have been supplemented by a flexure spring, but this is no ordinary laminated spring. On the Porsche the transverse spring consists of a single leaf of constant width, tapering steplessly from the middle to each end, so that uncontrollable static friction forces are not introduced into the suspension.



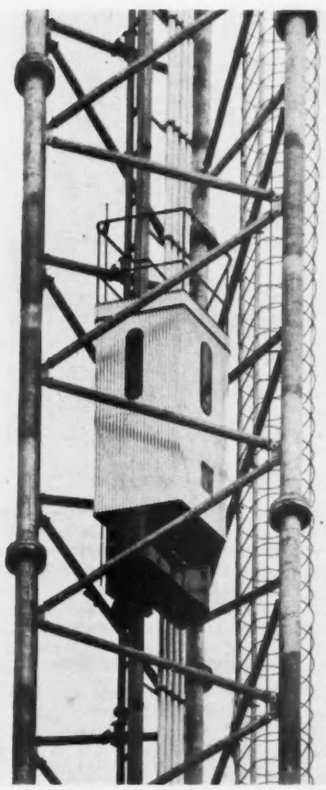
Peugeot 403 engine with Jaeger dry particle electromagnetic clutch in the fan drive: the brush can be discerned in line with the exhaust manifold

(*To be continued*)

Cableless Lift for TV Mast

FOR the maintenance of the structure and electrical installation of the 320m high television and radio mast at Hörby, Southern Sweden, Alimak-Verken A.B., Skellefteå, installed a cableless, climbing lift, driven by a two-stroke petrol engine through worm gears by means of a rack and pinion.

The mast is a tubular lattice tower of triangular cross-section. The lift runs inside on a guide rail bolted to the framework of one side. Ball-bearing rollers at the top and bottom of the cage guide it on the rail. For use in icy conditions the cage is equipped with an ice-breaking ram. The roof of the lift is built as a working platform. The climbing machinery, including the engine, is fitted under the floor of the lift.



Lift of Hörby television and radio mast. Self-propelled by a petrol engine and rack and pinion drive, it lifts a 255 kg payload to the service platform 245m above ground level

Arms which engage with limit switches inside the lift serve as endstops at the top and bottom positions. The limit switches cut off the engine's ignition current. For safety, sprung buffers are provided in both end positions, and a centrifugal catcher engaged automatically if the speed should tend to exceed 0·6m per second. This device can also be operated by hand from inside the cage. Floor, roof and supporting framework of the lift are of steel, while the walls are clad with corrugated sheet aluminium. Two trapdoor openings in the floor give access, one to the engine for such adjustments as cleaning the spark plug or carburettor, the other to the petrol tap. Another trapdoor in the roof and a fixed ladder are used for entering the lift ; opening of the roof door automatically cuts off the ignition. The working platform is protected by 1m high railings with folding bar for getting in and out.

The climbing machinery consists of a two-stage worm gear giving a 1 : 60 reduction. The worm wheels are fitted with electric couplings to give the same load on both wheels. Both the driving shafts are equipped with pinions meshing with the rack. The horizontal worms are connected with a ½in duplex roller chain, and the engine is directly coupled to the lower of the worms. The upper worm can be turned by hand through a crank with which it is connected by a chain drive and dog clutch.

The engine is a single-cylinder, 9·7 h.p. Sachs "200 LDR," two-stroke petrol engine with self-starter and reversible direction of running. It is fitted with intake air filter, exhaust pipe with heating jacket, silencer, built-in friction clutch and gearbox. The petrol tank, of $\frac{3}{16}$in thick sheet metal, holds 12 litres. It is insulated with 1½in of mineral wool and enclosed in galvanised sheet metal.

Controls include starting switch with key, choke, hand throttle, thermostat for cage heating system, clutch pedal, lamps showing direction of travel, charging control lamp and an inspection light socket outlet and switch. A portable CO_2 extinguisher is carried, the outlet hose of which is normally taken to the carburetter inside the engine housing.

The lift speed can be adjusted by the throttle in top gear up to a value of 0·3m per second, in either direction, or 0·21m per second and 0·14m per second in the two lower gears. The overall weight of the lift is 425 kg, of which 255 kg is payload. The cage has an outside height of 3800mm, and an internal height of 1985mm. The lift gives access to a platform on the tower 245m above ground level.

The Hörby television and radio mast was completed last October. Transmission is at 48·25 and 53·75 Mc/s with an effective radiated power of 75kW for image transmission and 15kW for sound. A further transmitter is being installed this spring. It will be possible to operate the two transmitters in parallel and in this way reach the maximum permissible radiated power of 100kW for image transmission and 25kW for sound transmission ; this, it is stated, will make Hörby the most powerful television transmitter in Europe. Two F.M. transmitters are also installed with a radiated power of 60kW, again the maximum which is permissible.

The base of the tower is at 162m sea level. The steelwork is supported by three sets of guy ropes, each consisting of four ropes, attached at the corners of the triangular sections. A 20m high top section was added for possible later use as an aerial for Channel 4. Underneath is a platform, and below this are the arrays of F.M. aerials. At a height of 245m, a service platform in the form of a crow's nest of 16 square metres floor area and 2·5m internal height has been fitted for use in connection with electronic measurements and maintenance. The next 43m below this level are occupied by the television aerials. At a height of 25m above the ground is a parabolic aerial providing contact with the Stockholm–Göteborg–Malmö television link.

Up to the 184m level an external ladder, surrounded by a guard, has been provided ; above this height, up to 300m, the ladder continues inside the tower.

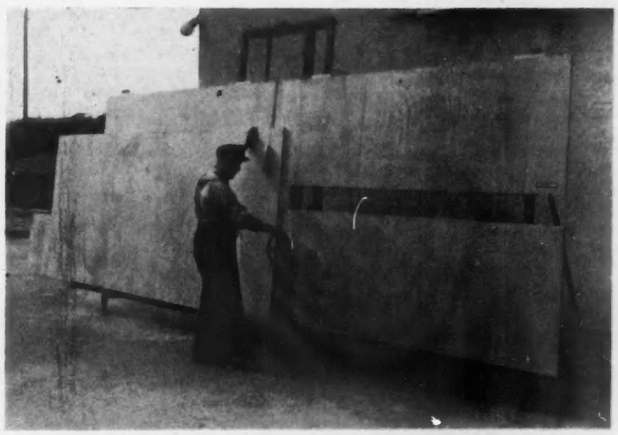
The weight of the tower structure itself is 131 tonnes, to which must be added 20 tonnes for the T.V. aerials and their attachments, and 16 tonnes for the cables, lift, and other equipment.

Panel Saw

We have received details of a panel saw made by Karl M. Reich Maschinenfabrik, Nürtingen (Württ.), and handled in this country by J.K.O. Cutters, Ltd., Hughenden Avenue, High Wycombe, Bucks. The machine, the "Holzher PKS" panel saw, is shown in the accompanying illustration. It is claimed that by its employment substantial savings can be achieved in many directions. Besides an increase in speed, the accuracy of cutting is improved to the extent that second operations are avoided. Panels of large size can be handled and cut by a single operator where usually two men are required, and owing to the fact that the material is in an upright position, the floor space taken up is very much less.

The panel saw, which was developed in co-operation with the Stuttgart Master Cabinet Makers' Association, can be used with panels up to 5·2m long, 2m wide, and 42mm thick ; for such panels the required floor space is only 5 square metres. Basically, the machine consists of a nearly vertical guide assembly to which are hinged lateral supports the length of which can be chosen to suit the largest sheet which is to be cut, in order to minimise the space required.

The circular saw is mounted on a guide column on which it is traversed by a cable equipped with counterweights, so that on completion of a cut the saw is returned to its starting position. The cable drive, by slipping, prevents damage from overload or faulty handling. Should the cable break, the saw is held in position by a safety device. For vertical cuts, the saw is traversed by means of a handwheel at the top of a column in front of the machine. A geared dustproof chain drive transmits the rotation of the wheel, the ratio being chosen in such a way that the machinist can readily operate the handwheel with one hand. For horizontal cuts or for positioning the panel, the column with the handwheel can be swung out of the way and laid down on the floor.



Panel saw for vertical and horizontal cutting of panels up to 5·2m by 2m

For horizontal cuts the saw is swivelled through a right angle and clamped in the same operation. In this case the sheets are fed by hand against the saw along a guide rail fitted with rollers.

The saw is equipped with a following supporting table the surface of which is flush with the side supports. This table safely supports even thin stock in the vicinity of the saw blade. For extremely thin material a special saw guard is available which is fitted to the riving knife under spring load, and holds down the stock on the table by means of laterally arranged rollers.

The circular saw is powered by a 1·4 h.p. universal a.c./d.c. motor which can be connected to the mains supply at any convenient point, such as remote storage sheds. Transport of the saw and re-erection are stated to be simple, even on ground which is not level. Standard universal as well as carbide-tipped blades are available.

CONTINENTAL AFFAIRS *(Continued)*

Savines Bridge

The impounding by the Serre Ponçon dam of the River Durance, the second largest tributary of the Rhône, is creating a reservoir of 2800 ha and a capacity of 1200 cubic hectometres, of which 900 cubic hectometres will be utilisable. When in full operation, Serre Ponçon will form the largest combined irrigation and hydro-electric power scheme in France, and will constitute a major element in the harnessing of the Durance.

The large area of water which is coming into existence behind the 120m high earthfill dam, and which approximates in size the Lake of Annecy, made it necessary to carry out substantial resiting of railways and roads. The most important single work in this connection is the viaduct on which the Route Nationale 94 from Gap is carried across the valley to join the Route Nationale 854 on the left bank near the township of Savines, which will be submerged.

The viaduct, shown in our accompanying illustration, is a prestressed concrete structure 924m long, comprising thirteen equal cantilever spans, of which the central ones are 77m and the end ones 38·5m long. These spans carry a 7m wide asphalted roadway and two 1m wide pavements.

The piers are also of prestressed concrete. They have a section of 5m by 5m and a uniform wall thickness of 40cm. The two tallest, on either side of the river, are 43m high. Their foundations are caissons sunk to the solid rock, but the remaining piers which are not endangered by underflow have plain footings set in the alluvial subsoil.

At the piers the girders have a box cross-section 5m wide and 4m high, so that the maximum height of the roadway above the valley is about 48m. At the piers the bottom slab of the bridge girders is 45cm thick but tapers to 18cm at the centre of the spans. The side walls have a uniform thickness of 40cm ; the top slab is 18cm thick and extends laterally beyond the box section.

Construction of the bridge occupied about one year and was concluded last November, well ahead of schedule. The procedure was to construct the piers with the help of rail-mounted tower cranes, concrete being mixed at several points along the line of the bridge. By means of formwork attached to the piers, the centres of the cantilevers were cast. After post-tensioning of the cables in these sections, the cantilevers were built outwards symmetrically on both sides in lengths of 3·5m. Mobile shuttering for the purpose was carried on scaffolding suspended from a 7·5m long girder running on wheels on the portion already completed, the overhang being balanced by a 33-ton mass at the tail end.

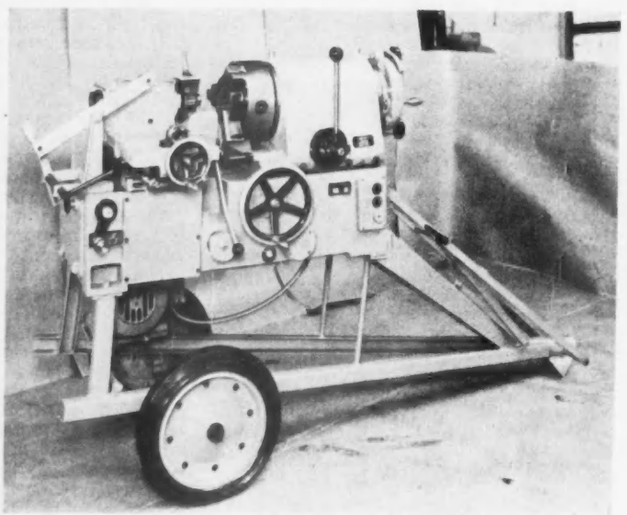
Each half girder contains seventy-two post-tensioning cables, system G.T.M., of 65 tonnes nominal capacity, and varying in length. Post-tensioning was carried out at each section in turn, as the work progressed, by means of hydraulic jacks. After loading the cable to 77 tonnes, equivalent to 200,000 lb per square inch, it was relaxed, then stressed again to the same figure and relaxed to 72 tonnes (185,000 lb per square inch, or 80 per cent of the ultimate strength), after which the ends were enclosed. Before grouting, the cable ducts were thoroughly cleaned of lubricant by pumping through a detergent. The estimated final stress in the cables, after shrinkage and creeping of the concrete, is between 156,000 lb and 170,000 lb per square inch.

Adjoining cantilevers are connected at the centre of each span by ball-and-socket joints, allowing for transmission of loads and expansion stresses. The design of the bridge lay in the hands of the Société d'Etudes et d'Equipements d'Entreprises (S.E.E.E.), and the contractor was the Société des Grands Travaux de Marseille.

The 924m long Savines Bridge, here shown near completion, crosses the valley of the Durance where it will be flooded by the Serre Ponçon reservoir

Automatic Tube-Cutting and Screwing Machine

Following the introduction by Ruhrstahl A.G., Brackwede, of the " R.G. " cutting and screwing machines some years ago, the same firm has now produced the " R.G.-Auto," claimed to be the first entirely automatic tube-cutting and screwing machine (agent : J. C. Neville, Ltd., 34, Priest's Bridge, London, S.W.14). Our accompanying illustration shows the machine, which is designed to cut, bevel and thread tube from ¼in to 4in diameter. Parallel or taper threads can be cut to British and foreign standards, without resetting of the tube when changing from cutting to threading or vice versa, and only minor adjustments when changing from one thread to another. The automatic operation is stated to eliminate any danger of overloading.



Automatic tube-cutting and screwing machine

Noiseless Blowpipe

For use with town gas (not butane or propane), N.V. Nederlandsche Instrumentenfabriek " Nonius," Delft, Surinamestr 5–7, has developed a glass-blower's blowpipe stated to be almost silent in operation. The burner, which is mounted on a swivel base, is fitted with a selector allowing it to be set for six different kinds of flame. The outer annulus of the burner is supplied with gas in the normal way, but the centre comprises three concentric nozzles for air, oxygen, or mixtures of the two. These may be used singly or in combination, and in this manner the different flame settings are obtained. There is a separate gas control valve. In addition, the maker states that needle valves should be fitted in the oxygen and gas lines ; these are also supplied and are designed for controlling pressure to about 1 atmosphere ; the needles are non-rotating. The blowpipe is available from Nonius, Ltd., 38, Beethoven Street, London, W.10.

Italian Machine Tool Fair

From October 7 to 16, the Biennial Italian Machine Tool Fair will be held at Milan. This exhibition covers Italian and foreign machine tools of all classes, testing machines, instruments, foundry plant, castings, welding machines and equipment, and heat treatment plant. Transfer machines, servo systems and hydraulic, pneumatic, electric, and electronic control equipment will also be covered. Full information may be obtained from the organiser, the Italian Machine Tool Manufacturers' Association, Unione Costruttori Italiani Macchine Utensili (U.C.I.M.U.), Via Palestro 22, Milan (telephone : 700.167, 700.353).

THE AMERICAN SCENE

by Our American Editor

Automatic Computers for Data Processing and Operations Analysis

AMONG the first areas in which the potentialities of automatic computation were exploited and its techniques adopted on a broad basis was the solving of the large accounting, operational, statistical and other special problems that arise in business, industry and Government. The intense activity of this kind which still exists is immediately evident in the number of data processing and operations analysis problems the National Bureau of Standards is called upon to solve. The demand for assistance in these relatively new areas is so great that, at present, such work accounts for about 20 per cent of the time the Bureau's I.B.M. 704 computer is in use and about one-third of the coding effort expended. Data processing and operations analysis problems come not only from the Bureau's staff but from other Government agencies who call upon the N.B.S. computing facility for help in applying electronic methods to information processing, information retrieval, accounting, reporting and large-scale analysis. To illustrate the scope of this work, some of the problems which have recently been solved or on which the Bureau is now working are discussed below.

"Autotag"

A war-game study called "Autotag," which simulates battles involving tanks and anti-tank systems, was programmed and carried out by the Bureau for the Combat Operations Research Group of Technical Operations, Incorporated. The use of computers to play war games in this way is becoming more and more frequent because the present development of weapons systems is so rapid that it is difficult to obtain the experience needed for competent tactical decisions. The computer, with its ability to simulate hundreds of manœuvres cheaply and rapidly, can in many cases provide an acceptable substitute for actual military exercises. In addition, the computer, instead of acting intuitively, can analyse numerous possible courses of action and supply the proper one for the battle situation at hand.

In the Autotag study, conducted by the Bureau's Computation Laboratory, a combat-simulation model was designed to evaluate the performance of anti-armour weapons systems in a variety of topographic and environmental situations. In any one simulation, each side may have up to thirty-one weapons which may be any or all of ten different types. Each weapon is specified by sixty-nine adjustable parameters. Some of these specify weapon type. They include, for example, maximum and minimum range, hit probabilities, probabilistic delay times for weapon action, dispersion of fire as a function of range, and kill-if-hit probabilities. Other parameters relate to a particular weapon and include position and velocity co-ordinates, status indications ("dead" or "visible to enemy," for example), and indices specifying the weapon's target selection rules.

Each side is also permitted up to seven mine fields and artillery fire at any of seven intensities before and during the battle. Two additional parameters specify the vulnerability of each weapon to mines and artillery. It is assumed that no weapon is ever "killed" by the artillery or mines of its own side. Simulations are carried out in sequences which include from one to fifteen games, differing only in the random numbers controlling the outcomes of probabilistic events. The results are recorded on magnetic tape and an additional computer routine later performs the necessary tabulations and statistical analyses. Detailed histories of each simulation are also preserved for further analysis.

Electro-Cardiograph Analysis

Under the sponsorship of the U.S. Veterans Administration, the Bureau is designing computer programmes that will analyse human heartbeats. The heartbeat data are in the form of electro-cardiograms which have been converted to digital readings by a method developed by the Bureau's Data Processing Systems Laboratory. The ability to provide a rapid, detailed analysis of such records suggests a method for improving the procedures employed in diagnosing various heart ailments.

The programming of the computer for this purpose is also being carried out by the N.B.S. Computation Laboratory. The immediate objectives are to detect the time intervals of important phases of the heart-beat cycle, to locate the least-squares planes in these cycles and determine the goodness of plane fit, and to find mean vectors, mean velocities, and the velocity variance. Although the time-interval detection has been found to be difficult and may not be suitable to digital methods, finding the means and the least-squares fits is a common digital problem. Digital methods are also immediately applicable to the analysis of these parameters, together with about 100 others, which will include age, weight and known diseases.

Low-Rent Housing Analysis

Under the sponsorship of the Public Housing Administration, the Bureau analyses for error the yearly reports on tenants in Federally-aided or -owned low-rent housing projects. This annual status examination is necessary to determine the tenants' eligibility for continued occupancy. Approximately 400,000 such examinations must be centrally edited for inconsistencies and prepared for statistical presentation. Inconsistencies and errors may occur among almost any combinations of the many items of data required for each tenant. These data include four items on income, nine on exemptions, two on rent, three on family composition, and others on age, race and call-up status, together with pertinent remarks where amplification is necessary. Also, the diversity of backgrounds among the individual respondents makes for further difficulty in predicting the volume and nature of errors likely to occur. It is therefore necessary to make numerous checks on the relationships among the several items of data.

To facilitate these editorial operations, the Data Processing Systems Laboratory developed a comprehensive computer programme. The initial step in preparing reports for input to the computer is the coding of remarks—a clerical operation performed in accordance with a simple two-digit code. Data cards are then punched from the reports and converted to magnetic tape. An additional input to the programme is the "project header file" which contains in one record per housing project all the rules governing the administration of that project, the name and the full address of the respondent, and various other project descriptions for statistical purposes. The main editing programme contains about 5800 computer instructions. Here the data are analysed critically for reporting inconsistencies and policy violations. Whenever an error is detected, it is recorded on magnetic tape. Six machine words are required to describe and index the error. Whenever possible, the programme corrects erroneous data and derives entries for items left blank. The data are further distributed into meaningful statistical arrays.

Another programme sorts the errors within each project by the assigned query numbers and writes an expository paragraph describing the inconsistency or violation. These paragraphs

Fig. 1—IBM 704 high-speed computer at the National Bureau of Standards

THE AMERICAN SCENE *(Continued)*

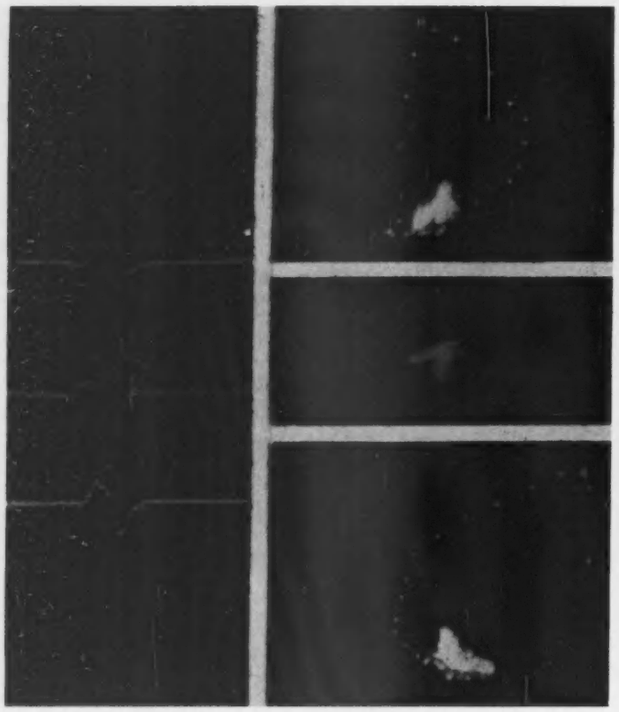


Fig. 2—Heart vector components seen on an oscilloscope (left) and as analysed by two-dimensional projections of the generated space curve (right)

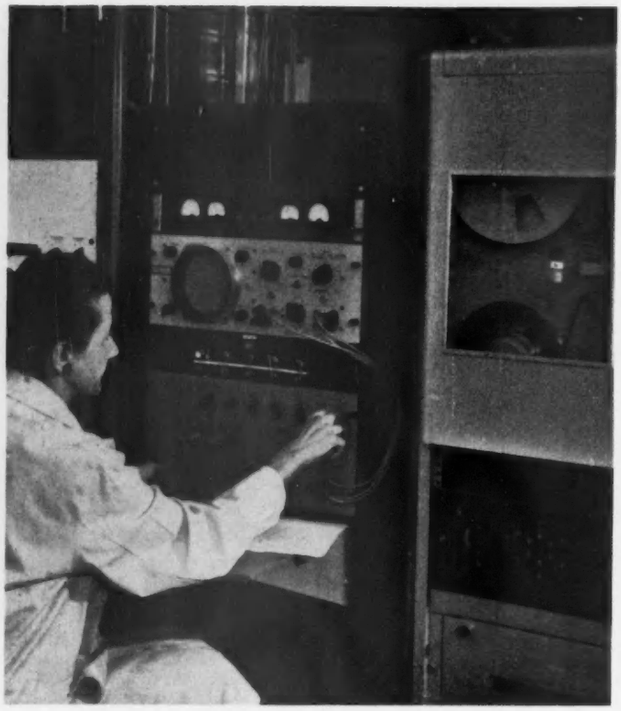


Fig. 3—N.B.S. analogue-digital converter for changing heartbeat data into a form suitable for computer use

become the substance of letters automatically generated and addressed to appropriate regional and project authorities. The names of the families involved are tabulated for printing following each paragraph. The letters are transferred to magnetic tape and are then ready for off-line productive printing on continuous-feed letter-head paper.

Payroll Operations

A programme that will allow the National Bureau of Standards to use a computer for generating payroll and other personnel services reports has recently been completed by the Computation Laboratory. This development was based on information obtained in an original study which the Data Processing Systems Laboratory conducted under the Bureau's programme of assistance to other Government agencies. The complexity of the present undertaking is indicated by the many reports and documents which must be considered. These include the master pay list, the payroll for personnel services, cheque issues and statements of earning, time cards, savings bond schedules and purchase lists, earning reports and P.A.Y.E. income tax statements.

Like many data processing problems, the payroll operation utilises a master tape, which in this case contains, for each employee, all pertinent information, such as name, pay rate and number of dependants. This master tape is continually up-dated by merging it with records of personnel actions such as new appointments, promotions and separations. From the up-dated master tape and the time-card information for a given pay period, the computer produces payroll reports. Test runs have shown that the computer can duplicate in a few minutes the work which it now takes approximately eighty man-hours to accomplish at each pay period.

Traffic Studies

The Bureau is engaged in programming and solving several data processing problems on traffic for the Bureau of Public Roads. This work is carried out by the Computation Laboratory and is basic to the effective design of new roads and highway networks. One important aspect of the investigations is the development of equations that will accurately predict traffic patterns. The Bureau is analysing data on traffic passing through a signal intersection in efforts to derive such equations. Part of the coding for this problem and an auxiliary code for the analysis of data on highway accidents have been completed. The results of the latter code, which relates the accident rate to control of road access, were requested by the Congress for a highway safety study it has authorised. Another problem, dealing with the assignment of projected traffic to existing and proposed routes, is handled by a programme which computes a "tree" of minimum travel-time paths from each point in an urban area to all other points. The Bureau's facilities are being used to make runs for the Washington area, the Minneapolis-St. Paul area and the Columbus area.

Linear Programming

The Bureau solves a variety of logistics problems quickly and easily by making use of a relatively new mathematical field known as linear programming. In applying linear programming to a problem the first step is to interpret mathematically the various conditions imposed. On the basis of this analysis, one of several linear programming computation procedures, previously coded for the computer, is applied to the data of the specific problem. The applicability of linear programming has greatly increased with the advent of high-speed computers, whose size and speed permit the treatment of larger and more complicated systems. Furthermore, the increasing availability of such advanced computers suggests that the utility of linear programming can be greatly extended. Already the Bureau is considering problems which are formally similar to those solved by linear programming techniques but have previously been thought to be beyond the scope of this method. Thus, mathematicians are investigating the reduction of very-large-scale systems by approximate and combinatory methods, non-linear programming and stochastic programming.

The Bureau is attempting to extend linear programming to a variety of problems ranging from the selection of frequencies for air navigational radio stations (at the request of the Federal Aviation Agency) to the allocation of medical supplies to hospitals through a depot system with variable unit costs of shipment and storage—a problem submitted by the Veterans Administration and the General Services Administration. Other work includes two studies for the Federal Communications Commission. In one, the Bureau is determining the optimum channel frequency and station location for commercial television stations. In the other, it is seeking the optimum trade-off time between service and inter-station interference in A.M. and F.M. radio stations.

Language Translation

The Bureau is engaged in a programme, sponsored by the U.S. Army Office of Ordnance, to develop mechanical translation techniques. The immediate objective of this work is to use an electronic digital computer to translate technical Russian into English. The mechanical translation studies, under the direction of the Bureau's applied mathematics staff, have resulted in a process which goes much further than the word-to-word translation ordinarily associated with computers. This method is designed to parallel the thinking of a human translator. Furthermore, it applies iteration to approach the correct syntactical interpretation of the Russian source sentence. The translation proceeds in three main steps : first, relevant information, stored in a machine glossary and auxiliary listings, is collected ; secondly, source words, symbols and punctuation marks are recognised by the use of this stored information, and the clause and phrase structure of the source sentence is tentatively determined ; thirdly, a structural analysis of the source sentence with simultaneous refinement of clause and phrase structure is made and the corresponding " pidgin " English is printed out. The heart of the method, which constitutes the contribution of the Bureau, is the prediction,

after each source word, of future occurrences on the basis of stored syntactical relationships between Russian words.

Automatic Design of Computers

The Bureau has devised techniques for using an existing computer to work out design details for new computers. The objective of this work, carried out under the direction of the Bureau's Data Processing Systems Laboratory, was to mechanise some arduous manual design procedures.

The procedure for designing a large-scale digital system involves four major steps: the preparation of system specifications; the organisation of the system into large-scale functional blocks; the creation of the detailed logical design for each of these functional blocks, and the conversion of this logical design into detailed wiring plans. In deciding which steps of this procedure should be mechanised, the primary criterion was whether a machine or an experienced computer designer could turn out a better end product. In some cases it was found that a machine could not effectively compete with the empirical intuition of the experienced logical designer; in other cases, the use of a machine permitted a degree of design sophistication, accuracy and efficiency not otherwise obtainable. On the basis of this criterion, the portion of the design procedure selected for mechanisation was the conversion of a logical design into detailed wiring plans. The conversion process was carried out automatically for a new large-scale computer system. Suitable programmes were written to provide a complete set of instructions for accomplishing the conversion of the computer logical design data. Methods for expressing the logical design data in machine language were worked out by the Data Processing Systems Laboratory. The input data consisted of approximately 20,000 punched cards which the computer used to produce the complete wiring plans for the new system.

The input transcriptions of the logical structure of the new system—expressed in terms of equations in Boolean algebra—were first checked rigorously for internal consistency. Then, using additional data describing the physical locations of the principal building blocks in the system, the computer automatically assigned the numerous minor components to optimum physical locations with respect to the principal blocks. The computer then calculated the optimal wire routing between every connected set of components in the system, taking into account the restrictions on wire lengths imposed by their electronic and mechanical properties. Next, a topological diagram of the wiring tree, showing the physical location of each node and its connections with the other nodes in the tree, was printed out. Finally, the computer calculated and printed out the exact lengths of all wires, specifying terminal types, pin-to-pin connections, the text for labels on the wires, and a detailed inventory of the components and materials used.

As an aid to maintaining the completed system, the machine also was used to generate detailed information on the inter-relations between the logical structure of the system and the actual physical equipment used to implement the logic. The final output data consisted of 15,000 printed pages containing the complete wiring plans for the new system and source material for the maintenance manuals.

Large Double-Focusing Mass Spectrometer

ONE of the world's largest and most precise instruments for determining the relative amounts and weights of atoms and for measuring the extremely small amounts of energy that hold the atomic nucleus together has been placed into operation in the Physics Building at the Argonne National Laboratory, Lemont, Illinois. The apparatus is a double-focusing mass spectrometer of 100in radius and will be employed by the Argonne Special Materials and Services Division. Under construction since 1954, the machine has been undergoing focusing and calibration tests since last July. The machine is shaped like a backward letter "S" in a plane parallel to the floor of the room in which it is operated. At one end of the "S" is a source of charged atomic nuclei. As the charged nuclei pass through the machine, they are sorted according to their relative weights in much the same manner that a light beam is sorted into its component colours when it passes through a prism. At the other end of the "S" is a very sensitive apparatus which measures the quantity of nuclei of each given mass.

A variety of experimental problems requiring high sensitivity and, simultaneously, high resolution will be studied with the new mass spectrometer. Some specific experiments requiring highly sensitive isotope analysis include: (1) Analysis of the isotopic composition of the very small amount of uranium in a meteorite sample for comparison with the isotopic composition of uranium on the earth. (2) A search for curium-247 in nature. (Curium-247 has been found in the debris of a nuclear explosion. It is thought that this isotope may exist in minute amounts in nature.) (3) A more accurate absolute measurement of the half-life of cæsium-137. The new spectrometer will extend considerably the mass spectrometric analytical investigations at Argonne. This work has resulted in the first identification of numerous isotopes, including some found in the debris of nuclear chain reactions. Among those identified at Argonne are the heavy element isotopes plutonium-244, curium-247, curium-248 and californium-251.

Another analytical application of the new mass spectrometer will be to determine what kinds of atomic nuclei are created when target atoms are bombarded by particles from a high-energy particle accelerator. The instrument will be used in this manner in conjunction with the Zero Gradient Proton Synchrotron now under construction at Argonne. Apart from its analytical applications, the instrument will be used to determine precisely the masses of species of atomic nuclei. Many of these nucleides of medium and heavy atomic weights have not been precisely measured.

The spectrometer is one of the largest mass spectrometers in the world. Other large machines

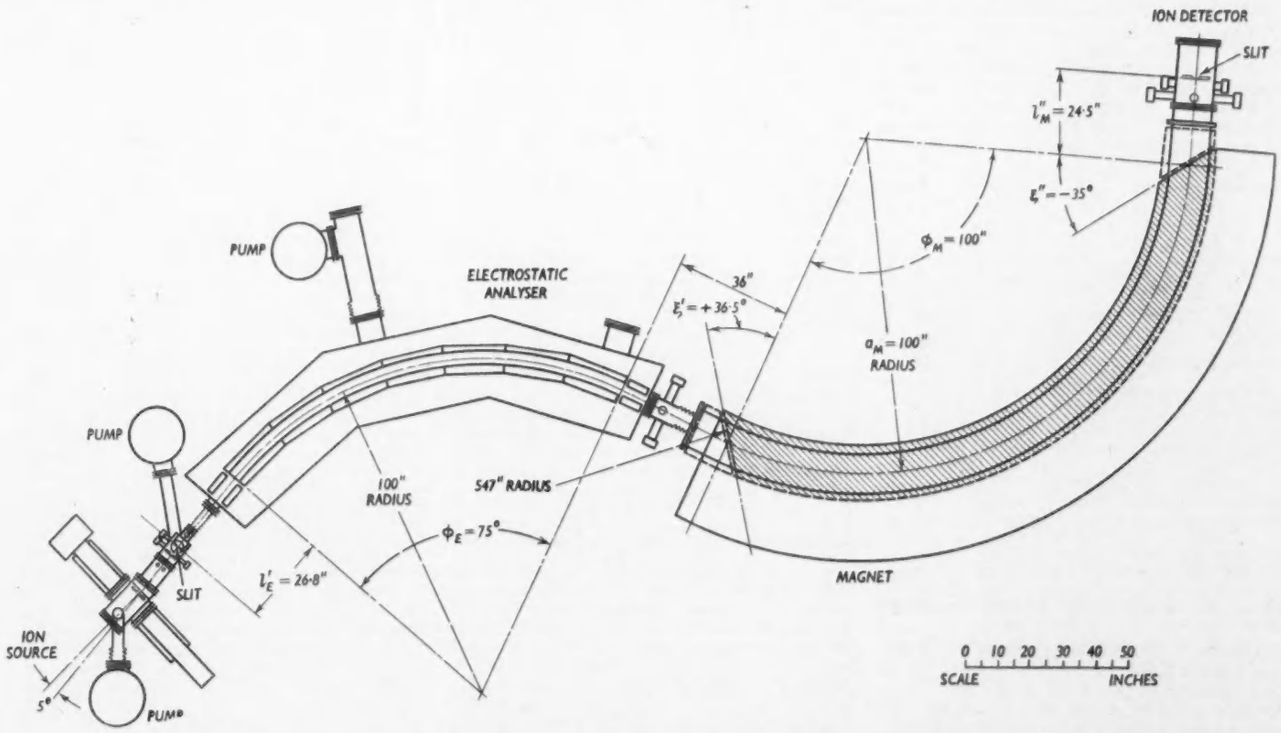


Fig. 1—100in radius double-focusing mass spectrometer

THE AMERICAN SCENE *(Continued)*

are at Harvard University, in Canada, in Germany, and in Japan. As illustrated in Fig. 1, the apparatus consists of four principal parts, the source unit where atoms are charged and accelerated into the machine, the electrostatic analyser where velocity differences of the charged atomic nuclei are compensated for, the magnetic analyser where the nuclei are " sorted " according to weight, and the collector unit where the ions are detected.

A sample of a substance to be analysed is introduced into the source unit. There it is

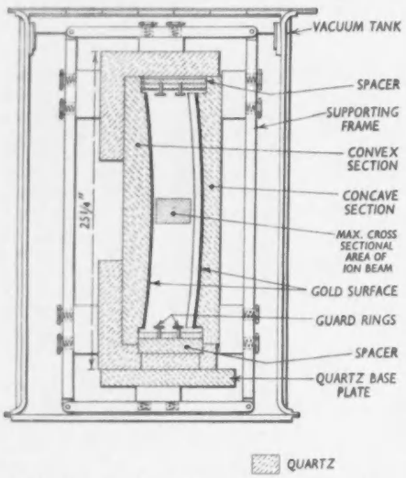


Fig. 2—Cross-sectional view of electrostatic analyser

vaporised, if it is not already a gas, and in the process its atoms are charged and accelerated into the machine at a highly stabilised energy of 50kV. The entire spectrometer has a very large aperture ; i.e. the transmission of ions from the source unit and the resolution of the ions at the collector are both very great. The instrument is designed to transmit more than 95 per cent of the ions produced in a conventional mass spectrometer ion source, with a resolution of 10,000. By comparison, the largest conventional analytical mass spectrometers transmit from 1 to 10 per cent of the ions, with a maximum resolution of 2000. A high vacuum of 10^{-6}mm of mercury is maintained throughout the mass spectrometer to allow an unrestricted motion of the ions. By maintaining high standards of

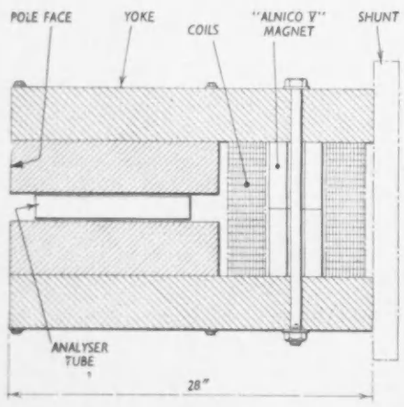


Fig. 3—Cross-sectional view of magnetic analyser

cleanliness in the assembly, it was found that this vacuum could be obtained without baking the apparatus to drive off impurities. Three mercury diffusion pumps with liquid air traps are employed to maintain the vacuum conditions.

The sample container is constructed so that it can be introduced into the source unit and removed without breaking the vacuum. In the source unit, the ions pass through electron-optical " lenses " which define the width of the beam and its angle of divergence in two directions. On leaving the source unit, the ions pass into the electrostatic analyser, which is shown in Fig. 2. This is a 75 deg. angle portion of a spherical condenser with 100in radius. It is composed of seven sections made of opaque fused quartz weighing a total of 1 ton. The sections together make up two concentric electrode surfaces covered with an oxide-bonded coating of gold. The quartz sections were ground to a smooth accurate curve in the applied physics laboratory at Boston University. The additional precise grinding and gold coating were done at Argonne. To obtain mechanical stability, the electrostatic analyser is mounted on a 5-ton slab of granite.

Fig. 3 shows the magnetic analyser, which is a 14-ton permanent magnet fabricated by the combined efforts of the United States Steel Corporation, the Crucible Steel Company, and the Argonne machine shops. Being a permanent magnet, it has a very stable field (2000 gauss). The magnet has parallel poles describing a 110 deg. angle section of a circle with a 100in radius. It is mounted on a movable carriage to allow for focusing.

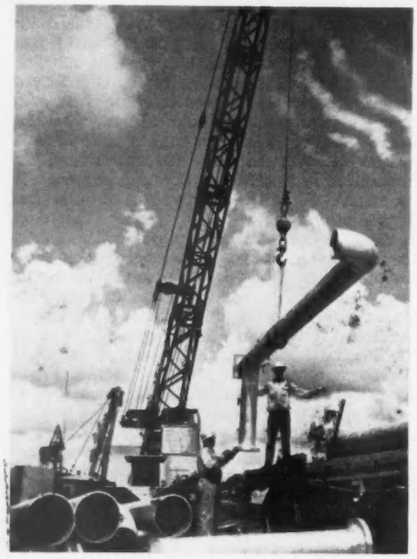
Ions leave the source unit of the mass spectrometer with slightly different velocities, fanning out in slightly different directions. It is the function of the electrostatic analyser to spread the ions in a parallel beam according to velocity and direction in such a manner that the magnetic analyser will focus them into sharp images, separated according to mass. In the electrostatic analyser the ions pass within the " walls " of a curved passage formed by the gold-covered quartz sections. The inner, convex, wall of the passage bears a negative charge, and the outer, concave, wall carries a positive charge. The slower-moving ions travel in paths with smaller radii of curvature, being attracted more to the inner wall than the faster ions. The operation of the magnetic analyser resembles the operation of the electrostatic unit except that the bending forces are dependent on the mass of the moving ions rather than their speed. Those ions with the least mass are pulled farthest toward the centre of curvature. Those with more mass are not pulled as far. The beam of ions thus becomes a spectrum of different masses. Emerging from the magnet at the collector unit, the ion beam is precisely focused into sharp images according to mass. The heaviest ions are on one side, the lightest on the other. If a piece of photographic paper were placed in front of the ion beam and exposed, it would show a series of lines, each made by ions of a different mass. Instead of photographic paper, the Argonne mass spectrometer uses a sensitive electron multiplier apparatus to detect ions emerging through a slit. This detecting apparatus can register a single ion.

The new instrument might be called a " 100in radius double-focusing mass spectrometer employing a special case of the Mattauch-Herzog focusing arrangement with beam parallel between the magnetic analyser and the electrostatic analyser." This focusing arrangement was first described by two European scientists, J. Mattauch and H. Herzog, in papers published in Germany.

Aluminium Pipeline for Natural Gas

AN aluminium natural gas line was recently installed in Baton Rouge, Louisiana, using over 1600ft of seamless pipe ranging in diameter from 4in to 14in. The above-ground line serves an alumina plant operated by the Kaiser Aluminum and Chemical Corporation, and is designed to deliver 50,000,000 cubic feet of natural gas daily. From supply header to pressure reducing station the working pressure is maintained at 250 lb to 300 lb per square inch gauge, although the high-pressure 10in aluminium pipe was hydrostatically tested to 750 lb per square inch gauge for two hours immediately after completion of the installation. In fabricating the line, the contractor used both tungsten-inert-gas (T.I.G.) and metal-inert-gas (M.I.G.) welding methods. The welders were trained and qualified in both methods to take advantage of the greater speed of the M.I.G. process in readily accessible locations and the easier handling of T.I.G. equipment in close quarters. All low- and high-pressure pipe used was extruded from the U.S. aluminium alloy 6061-T6.

The buried steel pipeline which formerly served the plant with gas from the Olin Gas



Fabricated section of a 10in diameter seamless aluminium pipe in course of erection into natural gas line

Transmission Corporation had been exposed during excavation, revealing severe corrosion. In designing the new aluminium line, it was decided to construct it above ground because of the presence of complex underground installations and major works streets. Standard weight seamless pipe is installed throughout the gas line. The 4in and 10in pipe conforms to the American " Schedule 40," while the 12in and 14in sizes have a wall thickness of 0·375in. The welding fittings and flanges were manufactured by Tube Turns, Incorporated, of Louisville, Kentucky, and are of forged 6061-T6 aluminium. To avoid galvanic corrosion where aluminium and steel meet at flanged connections, insulating kits are used consisting of a gasket, sleeves for all bolts, and insulating washers at each end of the bolts.

Because the pressure-reducing station is adjacent to an office building, the high noise level common to this type of installation made noise suppression necessary. This was accomplished by the use of long radius fittings, valves designed to offer a minimum turbulence in gas flow, silencers installed on the downstream side of the pressure-reducing valves and sound-deadening foam glass insulation inside the station. The primary advantages of aluminium in such a system are corrosion resistance both in above- and below-ground installations, increased gas flow because of smooth interior surface, and reduction in weight with no loss of strength. Furthermore, it was found that the higher material cost of aluminium is considerably offset by its lighter weight, ease of handling and elimination of maintenance painting. In addition, aluminium has the advantage of being non-sparking.

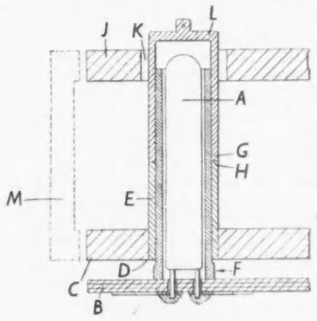
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

TELECOMMUNICATIONS

828,130. May 2, 1958.—MAGNETICALLY ACTUATED ELECTRIC SWITCH APPARATUS, Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2 (assignees of Bruno Dal Bianco and Mario Scata).

This invention relates to contact relay devices with armatures and contacts sealed in air-evacuated vessels and operated by exploiting changes in the magnetic reluctance of a magnetic circuit in which the devices are placed. The drawing shows such



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a sealed contact device *A* having its lower end secured to a plate *B* of insulating material on a surface of which runs the printed circuit or an equivalent electric circuit to be controlled, A first plate *C* of a magnetic material of high permeability, has a hole *D* into which fits a small tube *E* of magnetic material, also of high permeability, extending upwards half the height of the contact device. A tube *F*, of plastic, coats the inside surface of the tube *E* and extends upwards to receive a cap of magnetic material slidably mounted on tube *F*, so that its lower rim *G* comes in contact with the upper rim *H* of tube *E*. Parallel to plate *C* and spaced suitably therefrom, in accordance with the position of the armature (not shown), enclosed in the vessel, there is a second plate *J*, of magnetic material of high permeability. Plate *J* is provided with a hole *K* of suitable diameter, surrounding the cap *L* as this cap must move axially in this hole. Opposite magnetic polarities may be applied to plates *C* and *J* respectively, and may be obtained by placing one or more straight magnets *M* between them. If north polarity is applied to plate *J* the magnetic flux lines will pass through the gap of the hole *K*, reach cap *L*, and pass through tube *E* to plate *C* completing the magnetic circuit. Plate *C* will carry south polarity as a result of being in contact with the other end of magnet *M*. The armature of device *A* is magnetically shielded by the cap *L* and by tube *E* itself, but if cap *L* is slightly raised the magnetic flux will flow now through the magnetic members of device *A*, and the electric contacts thereof will be operated (making or breaking). Drive of cap *L* can be performed by known methods, i.e. pulling, rotation, pushing, falling, &c.; drive operation being manual or by electromagnets provided with suitable levers. This method to control indirectly magnetic contact-carrying armatures enclosed in protective vessels, using a permanent magnetic field, renders it possible to control a plurality of contact units, combining them in series or parallel groups, &c., and can be used to form selector switches, line finders, &c., employed in switching circuits, i.e. telephone switching systems. —*February* 17, 1960.

HYDRAULIC PUMPS

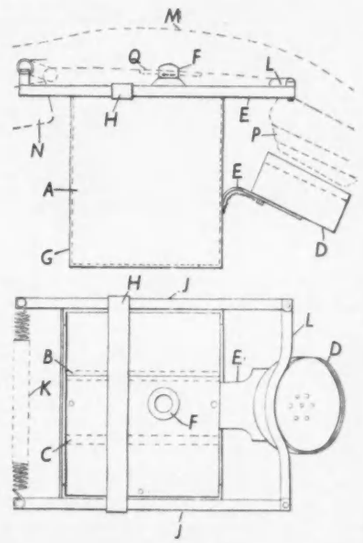
827,756. December 20, 1957.—MULTI-CYLINDER HYDRAULIC PUMPS, Dowty Hydraulic Units, Ltd., Ashchurch, Tewkesbury, Gloucester, and Oswald Thoma, of the company's address.

This invention relates to multi-cylinder radial hydraulic pumps or motors, and in particular to pumps or motors in which the cylinders lie outermost and the pistons have connecting rods working against an eccentric rotatable about the central axis of the pump or motor. The invention is concerned with an improved valve arrangement for the passage of hydraulic liquid to and from the cylinders, and its main object is to minimise friction while maintaining a satisfactory liquid seal between the working faces of the valve. Another and more specific object is to provide inlet and outlet valve ports in a valve plate of small radial compass, in which the valve plate is pressure loaded somewhat in excess of the hydraulic separating force at the valve interface irrespective of the direction of rotation of the pump or motor. The invention contemplates the provision of a circular valve plate, the whole area of which is used for pressure loading and is divided into an eccentric circular area and a surrounding crescent-shaped area equal one to the other, the two areas being respectively connected with the two main ports of the pump or motor.—*February* 10, 1960.

MARINE EQUIPMENT

828,227. October 30, 1956.—ALARM SIGNAL GENERATOR, International Marine Radio Company, Ltd., Intelco House, 21, Progress Way, Croydon, Surrey (communicated by A/B Standard Radiofabrik, Johannesfredsvagen 11, Bromma, Sweden).

It is an object of the present invention to provide a more convenient form of generator for providing characteristic modulation of a ship's radio telephony transmitter in case of emergency. The drawings show the container of an alarm signal generator comprising a box *A* having two loose partitions or intermediary walls *B* and *C*, the wall *C* constituting a terminal block for the oscillator of the alarm signal generator and the wall *B* dividing off a portion for its battery. A loudspeaker *D* is attached to one side of the box by means of a resilient member *E*. In one part of the lid there is mounted a uni-polar push-button operable switch *F* of such a design that the switch is closed only as long as the push-button remains manually actuated. The box *A* is placed in a U-shaped holder *G* of sheet metal and fixed by means of a metal strip *H* slidable along two bars or beams *J*. The supporting arrangement for the box comprises a helical spring *K*, bars or beams *J* and



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a bail member *L*, which together are for supporting an external telephone handset in the position indicated at *M*. In the position of the handset shown its receiver *N* is hung over the helical spring while its microphone *P* rests against the bail member *L*. In this position the handset switching contacts *Q* are actuated and this causes high tension voltage to be applied to the transmitter (not shown). Simultaneously the switch *F* is closed, causing the battery to be connected to the oscillator, which starts to work. The two-stage transistor oscillator (the circuit of which is shown in the specification) alternately generates electrical signals at 1300 c/s and 2200 c/s, and causes signals at these frequencies to be emitted from the loudspeaker. The signals are fed into the microphone of the handset, which is kept close to the loudspeaker by means of the bent shape of the bail member. Since the loudspeaker is resiliently supported it may be adjusted to various types of handset and shapes of microphone. Continuous modulation will be obtained as long as the handset occupies the position shown. The use of a battery as the source of current supply makes the device independent of the various supply voltages available on ships and renders the installation of the device relatively simple. The battery is an ordinary torch battery.—*February* 17, 1960.

SHIPBUILDING

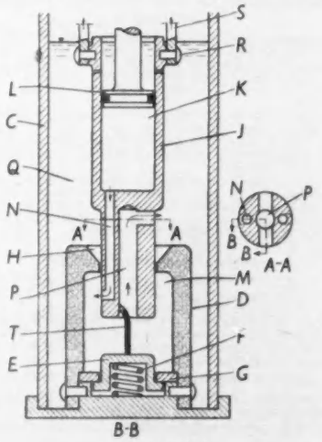
827,908. September 2, 1958.—STABILISER FIN ARRANGEMENTS FOR SHIPS, Muirhead and Co., Ltd., Elmers End, Beckenham, Kent. (*Inventor: John Bell.*)

In one type of fin arrangement used for ships stabilisation the main fin has attached to it a tail fin or flap which is caused to oscillate or tilt through a greater angle than the main fin and thereby increase the lift so that a lift coefficient significantly greater than that associated with a simple aerofoil section is made available. The construction of such an arrangement as a telescopic fin or a fin to be retracted into the vessel is somewhat difficult, and it is an object of the invention to provide an equivalent construction which avoids this difficulty. It consists of a stabiliser in which a main fin has a separate auxiliary fin on each side which is also rotatable in time with the main fin to increase its lift in each of the two directions of deflection. A fin and two auxiliary fins according to the invention result in the equivalent of the flapped fin when the fins have been moved to their appropriate deflection in either direction. More than two auxiliary fins may be spaced at different distances from the neutral plane of the main fin; these would be deflected proportionally to the main fin but to a greater extent, the angle of deflection of the auxiliary fins being arranged according to the requirement of obtaining the best flow and lift from the complete assembly.—*February* 10, 1960.

ELECTRICAL ENGINEERING

828,520. May 14, 1958.—OIL CIRCUIT BREAKER, Allmanna Svenska Elektriska Aktiebolaget, Västeras, Sweden.

In circuit breakers in which a stationary contact is arranged in a confined extinguishing chamber and a movable contact is arranged to traverse an opening in the wall of the extinguishing chamber, the gas pressure is increased with increasing interrupted current. As the gas pressure acts on the movable contact in the same direction as the force exerted from the operating mechanism, the speed of the



No. 828,520

movable contact will increase with increasing current. According to the present invention, however, the speed of the moving contact is independent of the pressure in the extinguishing chamber and thus also independent of the interrupted current. One form of oil circuit breaker in accordance with the invention is shown in the drawings, the smaller drawing being a section of the movable contact along *A-A* in the larger drawing. The section through the movable contact in the larger drawing is taken along the line *B-B* of the smaller. Referring to the drawings, *C* designates a container partly filled with oil. At the bottom of the container an extinguishing chamber *D* of electrically insulating material is attached. In the lower part of the extinguishing chamber the

stationary contact of the breaking gap is arranged, comprising a yieldably-mounted contact block *E* which is actuated by a spring *F* in the direction towards a locking ring *G*. The extinguishing chamber is provided in its upper part with an opening *H*, which is traversed by the movable contact *J* of the circuit breaker. The movable contact is provided in its upper part with a cylindrical space *K* which is closed in its upper part with a stationary piston *L* and which is in communication with a space *M* in the extinguishing chamber through channels *N*. The movable contact is also provided in its lower part with a central channel *P*, by which the space *M* communicates with a space *Q* outside the extinguishing chamber. Breaking gases developed in the extinguishing chamber can escape through this channel. The movable contact is connected by pivots *R* to two rods *S* which are joined with an operating mechanism (not shown). The letter *T* designates an arc formed between the contacts of the circuit breaker.—*February* 17, 1960.

Catalogues and Brochures

ETHER, Ltd., Tyburn Road, Birmingham, 24.—Leaflet describing "Xactrol" potentiometer recording controllers, series 2000.

TURNERS ASBESTOS CEMENT COMPANY, Ltd., Trafford Park, Manchester, 17.—Leaflet entitled "Fire Protection of Structures."

EKCO ELECTRONICS, Ltd., Southend-on-Sea, Essex.—Catalogue of nucleonic instruments for use in medicine, industry, research and reactor instrumentation.

WHITEHOUSE INDUSTRIES, Ltd., Ferrybridge, Knottingley, Yorkshire.—Leaflet giving details of self-locking nuts with replaceable coloured plastic caps.

CLAUDE LYONS, Ltd., Valley Works, Ware Road, Hoddesdon, Herts.—Catalogue No. S-592, entitled "Automatic Voltage Regulators and Stabilisers," and catalogue No. V-599, describing "Variac" adjustable auto-transformers. Both catalogues contain details of new models.

B. AND F. CARTER AND CO., Ltd., Power Transmission Division, Albion Works, Bolton.—Leaflet P1, giving technical details of automatic spring controlled centrifugal clutches and P2, describing infinitely variable speed units, stock sizes ¼ h.p. to 2½ h.p. at 1440 r.p.m. input speed.

ELECTRICAL DEVELOPMENT ASSOCIATION, 2, Savoy Hill, London, W.C.2.—Paper entitled "Electricity and Problems of Animal Environmental Control," by Dr. D. W. B. Sainsbury, which was read at the E.D.A. Rural Electrification Conference, 1959, at University of Nottingham School of Agriculture, Sutton, Bonington.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., 82, York Way, King's Cross, London.—A brochure, "Signalling for Railway Modernisation," illustrating completed installations and work in progress on British Railways, London Transport, and overseas; also individual publications describing in detail the company's d.c. or carrier C.T.C. system and signalling for marshalling yard installations at Cowlairs, Newcastle, St. Pancras and Temple Mills.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, March 25.—COVENTRY AND DISTRICT BRANCH: E.M.E.B. Sports and Social Club, Merrick Lodge, Sandy Lane, Coventry, "Modern Light Sources," W. A. R. Stoyle, 7.45 p.m.

Mon., March 28.—NORTH WEST LONDON BRANCH: Compass Hotel, Watford, "Industrial Lighting," C. W. Embers, 8.15 p.m.

Tues., March 29.—EAST KENT BRANCH: Factory Visit to Pfizer, Ltd., Sandwich, 7.30 p.m.

Thurs., March 31.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "Floor Warming," R. Siverns, 7.30 p.m.

Fri., April 1.—BIRMINGHAM BRANCH: Visit to Central Telephone Exchange, 7 p.m. ★ LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, "Inspection and Testing of Plant and the Relationship to Safety and Protection," F. E. Noakes, 7.30 p.m.

BRITISH COMPUTER SOCIETY

Tues., April 5.—MANCHESTER BRANCH: Manchester College of Science and Technology, Sackville Street, Manchester, "Choosing and Installing a Computer—A Case Study," A. J. Platt, 7 p.m. ★ NEWCASTLE BRANCH: University Computing Laboratory, 1, Kensington Terrace, Newcastle upon Tyne, "Feasibility Studies and Fundamental Thinking on Integrated Systems," R. M. Jacobs, 7 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Thurs. and Fri., March 31 *and April* 1.—Town Hall, Royal Leamington Spa, Midlands Management Conference, 1960.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, March 25.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Drummond Street, Edinburgh, "Radio Guidance in the Automatic Landing of Aircraft," J. Shayler, 7 p.m.

Tues., March 29.—SOUTH MIDLANDS SECTION: Winter Gardens, Malvern, "Microwave Propagation—Some Characteristics and Curiosities," M. W. Gough, 7 p.m.

Wed., March 30.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Silicon Photo-Voltaic Cells for Instrumentation and Control Applications," V. Magee and A. A. Shepherd, 6.30 p.m. ★ SOUTH WESTERN SECTION: School of Management Studies, Unity Street, Bristol, "Training for Operating and Maintaining Television Studio Broadcasting Equipment," K. R. Sturley and A. E. Robertson, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., March 29.—Cleveland Technical College, Corporation Road, Redcar, "Prevention of Accidents in the Building Industry," J. A. Hayward, 7.15 p.m. ★ College of Technology, Howard Street, Rotherham, "Practical Formwork Design and Construction of Concrete," J. G. Richardson, 7.15 p.m.

Thurs., March 31.—Municipal Technical College, Blackburn, "Prestressed Concrete," H. Kaylor, 7.15 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., April 6.—SOUTHERN REGION: St. Ermin's Hotel, Westminster, London, S.W.1, Discussion on "The Advantages and Economics to be Derived from Automatic Control on Boiler Plants from 10,000 lb per hour up to 50,000 lb per hour," to be opened by W. A. Mather, 10.30 a.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., March 29.—SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, Annual General Meeting, and "The New Metals," J. R. Crane, 7.30 p.m.

INSTITUTE OF FUEL

Fri., April 1.—SOUTH WALES SECTION: South Wales Institute of Engineers, Park Place, Cardiff, "The Benson Boiler," four papers by staff of the Steel Company of Wales, 6 p.m.

Tues., April 5.—NORTH-EASTERN SECTION: Chemistry Lecture Theatre No. 3, King's College, Newcastle upon Tyne, Annual General Meeting, 5.30 p.m.

INSTITUTE OF METALS

Tues. to Thurs., March 29 *to* 31.—Church House, Great Smith Street, London, S.W.1, Spring Meeting, 1960.

INSTITUTE OF PETROLEUM

Wed., April 6.—61, New Cavendish Street, London, W.1, "The Systematic Prediction of Refinery Utilities," F. P. Alban, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., April 7.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, Joint Meeting with the Low Temperature Group of the Physical Society, "Some Problems Associated with the Use of a High Speed Reciprocating Compressor for Aircraft Cooling Projects," J. D. Gurney, 5.30 p.m.

INSTITUTE OF SHEET METAL ENGINEERING

Wed., March 30.—WOLVERHAMPTON SECTION: Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, Annual General Meeting, and "Tool Steels," C. L. Hellberg, 6.45 p.m.

INSTITUTE OF WELDING

Tues., April 5.—SLOUGH SECTION: Lecture Hall, Community Centre, Farnham Road, Slough, "Shop Inspection of Welds," 7.30 p.m.

INSTITUTION OF AGRICULTURAL ENGINEERS

To-day, March 25.—WEST MIDLANDS CENTRE: Hotel Leofric, Coventry, Annual General Meeting, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., April 5.—MIDLANDS BRANCH: Chemical Engineering Department, The University, Edgbaston, Birmingham, 15, papers on "Aspects of Process Economics," and "The Chemical Engineer and His Position in Management," 9.30 a.m. to 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 29.—TRAFFIC ENGINEERING STUDY GROUP: Great George Street, Westminster, London, S.W.1, Informal discussion on "Parking," introduced by R. Nicholas, 5.30 p.m.

Tues., April 5.—Great George Street, Westminster, London, S.W.1, "The Economics of Waste Water Treatment," C. B. Townend, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, March 25.—NORTH EASTERN GRADUATE AND STUDENT SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Reactor Instrumentation," R. G. Gold, 6.30 p.m.

Sat., March 26.—LONDON GRADUATE AND STUDENT SECTION: Visit to Tower Bridge (Bridge Operating Mechanism), 3 p.m.

Mon., March 28.—EAST ANGLIAN SUB-CENTRE: Assembly House, Norwich, "Submersible Pumping Plant," H. H. Anderson and W. G. Crawford, 7.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Donnan Laboratories, Vine Street, Liverpool, Annual General Meeting, and "Dangerous Electric Currents or Quantitative Effects of Electric Shock on Man," Charles F. Dalziel, 6.30 p.m. ★ NORTH WESTERN CENTRE: Technical College, Bolton, Discussion on "What Fundamental Principles Should be Illustrated in Electrical Engineering Courses," opened by F. C. Williams, 6.15 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, "Television on Tape," W. Silvie, 6 p.m. ★ WESTERN UTILIZATION GROUP: S.W.E.B. Demonstration Theatre, Colston Avenue, Bristol, "The Factories Act—Electricity Regulations," S. J. Emerson, 6 p.m.

Tues., March 29.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Place of Illumination in Electrical Engineering," opened by G. F. Freeman, 6 p.m. ★ LONDON GRADUATE AND STUDENT SECTION—CHELMSFORD DISTRICT: Eastern Electricity Board's District Offices, Anchor Street, Chelmsford, Essex, "Electrode Boilers for Industrial Process Work and Off-Peak Thermal Storage Heating Systems," G. A. Williams, 7 p.m. ★ NORTH MIDLAND CENTRE: Electrical Engineering Department, The University, Leeds, Discussion on "Teaching of Servo-Mechanisms," opened by P. H. Walker, 6.30 p.m. ★ NORTH MIDLAND CENTRE: Headquarters Mess, School of Signals, Catterick Camp, Catterick, "Progress on Problems of Ionospheric Propagation During the International Geophysical Year," W. R. Piggott, 6.15 p.m.

Wed., March 30.—LONDON GRADUATE AND STUDENT SECTION: Visit to Thames Navigation Service Building, Gravesend, 3 p.m. ★ SHEFFIELD SUB-CENTRE: Grand Hotel, Sheffield, "The Design and Performance of Zeta," R. Carruthers, 6.30 p.m. ★ SOUTHERN CENTRE: Burlington Hotel, Eastbourne, "The Provision of Adequate Electrical Installations in Buildings," (*a*) "Commercial Buildings," E. E. Jacob, and (*b*) "Small Industrial Premises," J. A. Sharp, 7 p.m.

Thurs., March 31.—ORDINARY MEETING: Savoy Place, London, W.C.2, Fifty-First Kelvin Lecture, "Cosmic Radiation," C. F. Powell, 5.30 p.m. ★ NORTH EASTERN GRADUATE AND STUDENT SECTION: Technical College, Sunderland, "Cooling of Large Alternators," R. M. Gledson, 6.30 p.m. ★ NORTH MIDLAND CENTRE: Y.E.B. Offices, Ferensway, Hull, "Recent Developments in Colour Television," I. J. P. James, 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., April 6.—MIDLANDS BRANCH: Queens Hotel, Birmingham, "Developments in Precision Hollow Forgings," H. D. Challen, 7 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., March 29.—39, Elmbank Crescent, Glasgow, "The Design of Ships' Interiors," M. Black and K. Bayes, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Wed., March 30.—EAST ANGLIAN BRANCH: Assembly House, Theatre Street, Norwich, Annual General Meeting and Film Show, 6.45 p.m.

Fri., April 1.—LONDON BRANCH: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Modernisation of the London-Brighton Trunk Road, A.23," L. G. Williams, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues., March 29.—EDUCATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Need for Post-Graduate Refresher Course for Engineers in Industry," 6 p.m. ★ NORTHERN IRELAND BRANCH: Central Hall, Belfast College of Technology, Belfast, Repetition of the London Graduates' Annual Lecture, "Design and Development of Machine Tools," C. A. Sparkes, 6.30 p.m. ★ WESTERN BRANCH: Engineering Laboratories, The University, Bristol, "The Jodrell Bank Radio Telescope," H. C. Husband, 6.30 p.m.

Wed., March 30.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "By-pass versus Full-Flow Filtration," 6 p.m. ★ EAST MIDLANDS BRANCH: Technical College, Lincoln, "Altitude Testing of Aero Engines," G. E. Watt, 7.15 p.m. ★ LUTON A.D. CENTRE: Royal Hotel, Mill Street, Luton, Crompton-Lanchester Lecture, "Structure of the Automobile," Maurice Platt, 7.30 p.m. ★ SOUTHERN GRADUATES' SECTION: Technical College, Brighton, Annual General Meeting, 7 p.m. ★ SOUTH WALES GRADUATES' SECTION: Park Hotel, Cardiff, "Wire-Drawing Machinery," N. A. Makin, 6.30 p.m.

Thurs., March 31.—EASTERN BRANCH: Good Companion's Hotel, Stoke Poges Lane, Slough, Annual General Meeting, and "The Performance of Vehicles Under Trans-Antarctic Conditions," D. L. Pratt, 7.30 p.m. ★ SOUTHERN BRANCH: Social Club, Saunders-Roe, Ltd., Cowes, Isle of Wight, "The Role of the Petroleum Industry in World Power Development," K. E. W. Ridler, 7.30 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, "The Elimination of Air Pollution from Road Vehicle Exhaust Gas," A. Fitton, 6.45 p.m. ★ EASTERN GRADUATES' SECTION: Old Manor House, St. Margarets Green, Ipswich, Film Show, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: College of Art, Green Lane, Derby, Annual General Meeting and Brief papers, 7.15 p.m.

Sat., April 2.—EAST MIDLANDS GRADUATES' SECTION: Visit to the British Thomson-Houston Company, Ltd., New Parks Boulevard, Leicester, 10 a.m.

INSTITUTION OF PLANT ENGINEERS

Tues., March 29.—SOUTH WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, and Technical Films, 6.30 p.m.

Thurs., March 31.—NORTH EAST BRANCH: Three Tuns Hotel, Durham City, "Type and Application of Plant for Open-Cast Coal Extraction," H. Briggs, 7 p.m. ★ SHEFFIELD BRANCH: Grand Hotel, Sheffield, "The Work of the City Engineer's Department," J. E. Kirkham, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., March 28.—NORTH WESTERN REGION AND GRADUATES' SECTION: Reynold's Hall, Manchester College of Science and Technology, Sackville Street, Manchester, Annual General Meeting, and "Economics of Machine Tool Purchase," J. Borsay, 6.30 p.m.

Wed., March 30.—MIDLANDS REGION: Technical College, Shrewsbury, Annual General Meeting, and Film Show, 6.45 p.m.

Thurs., March 31.—NORTH MIDLANDS REGION: Ruston Club, Lincoln, Annual General Meeting, and Film Show, 7.30 p.m. ★ SOUTH EASTERN REGION: College of Technology, Room 233, Luton, Annual General Meeting, and Film Show, 7.30 p.m. ★ SOUTHERN REGION: George Hotel, Reading, Annual General Meeting, "Production Depends on Communication" A. C. Leyton, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, March 25.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Birmingham, "The Structural Use of Prestressed Concrete in Buildings C.P. 115," A. W. Hill, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 25.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Application of Dimensional Tolerances," R. J. Herbert, 7 p.m.

Fri., April 1.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Kariba Hydro Electric Scheme on the River Zambezi," T. A. L. Paton, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, March 25.—Engineers' Club, Albert Square, Manchester, 2, Annual General Meeting; and "The Design and the Erection of the Atomium," F. Hebrant, 6.45 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., April 7.—Wigan and District Mining and Technical College, Wigan, "Hydraulics on Armoured Flexible Conveyors," C. L. Goddard, 4 p.m.

NEWCOMEN SOCIETY

Wed., April 6.—Science Museum, South Kensington, London, S.W.7, "Some Windmill Fallacies," Rex Wailes, 5.30 p.m.

N.E. COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, March 25.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Manufacture of Doxford Crankshafts," R. Atkinson, 6.15 p.m.

PLASTICS INSTITUTE

Wed. and Thurs., March 30 *and* 31.—William Beveridge Hall, London University, Senate House, London, W.C.1, Conference on "Polymeric Progress," Wed., 9.30 a.m.; Thurs., 9.15 a.m.

REINFORCED CONCRETE ASSOCIATION

Tues., April 5.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "Precasting in Concrete Framed Construction," J. F. Greinig and R. C. Westbrook, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

To-day, March 25.—MAN-POWERED AIRCRAFT GROUP: Library, 4, Hamilton Place, London, W.1, "Aerodynamics of Man-Powered Flight, with Special Reference to Inflatable Wings," D. Perkins, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 4.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Professional Negligence," C. A. Martin French, 5.45 p.m.

ROYAL SOCIETY

Thurs., March 31.—Burlington House, London, W.1, "Science in the Ceramic Industry," N. F. Astbury, 4.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., March 30.—John Adam Street, Adelphi, London, W.C.2, "Problems, Future Developments and Prospects of the Internal System of Transport," D. L. Munby, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Tues., March 29.—GLASGOW GROUP: Royal College of Science and Technology, Glasgow, C.1, "A Traffic Survey in the Central Area of Glasgow," T. B. McKenna, 7.15 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., April 6.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Spring Lecture, "The Presentation of Corrosion Information," J. W. Jenkin, 6 p.m.

SOCIETY OF ENGINEERS

Mon., April 4.—Geological Society, Burlington House, London, W.1, "Research Testing," A. E. Bingham, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., March 29.—Manson House, 26, Portland Place, London, W.1, "Application of Transistors in Instrumentation," G. G. Bloodworth, 6.30 p.m.

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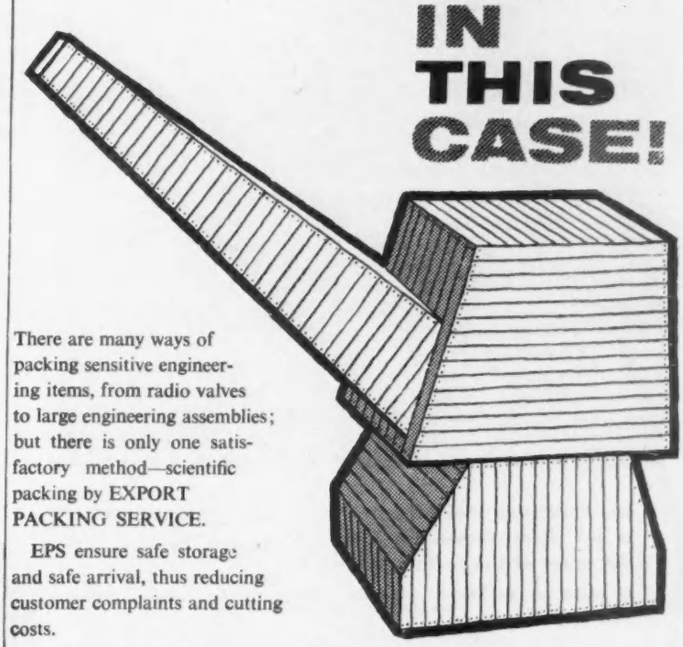

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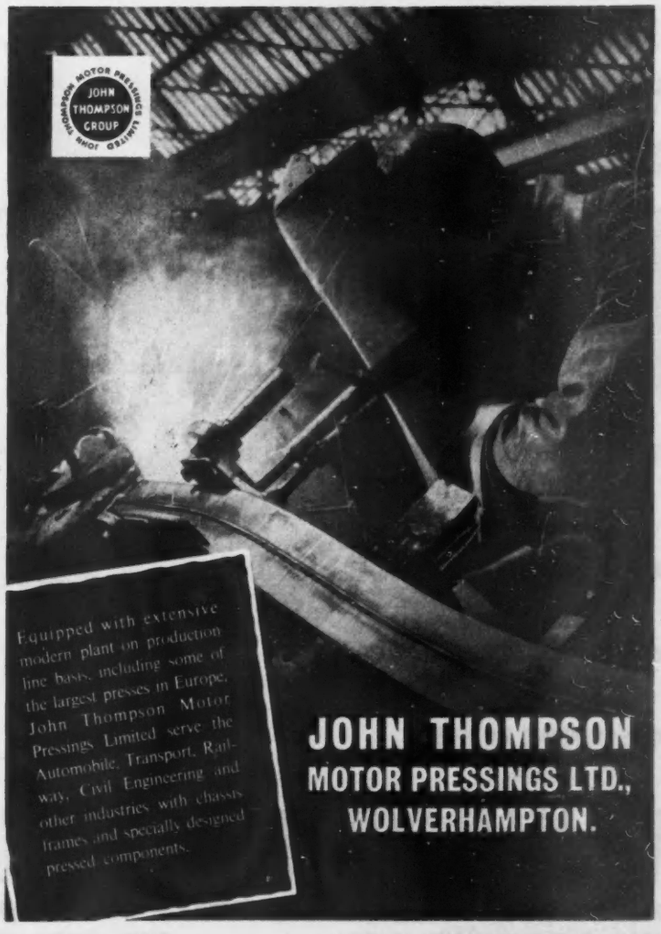
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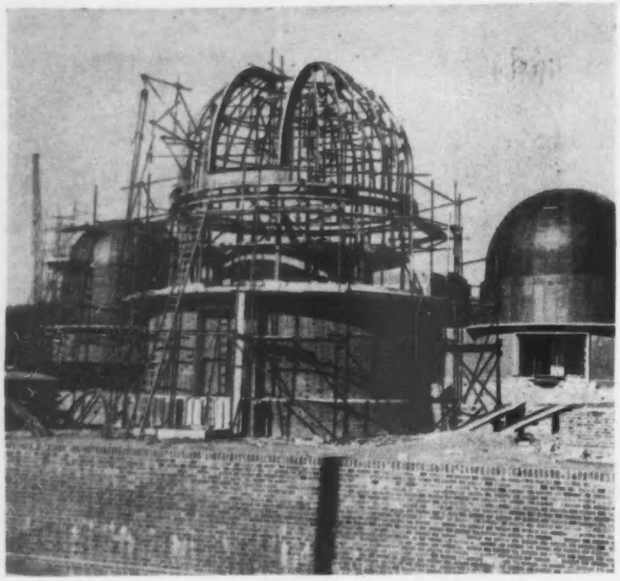

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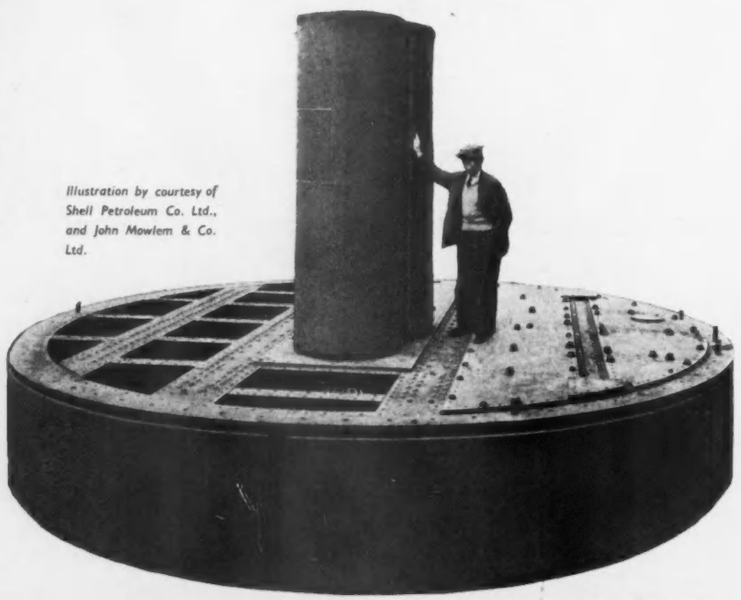

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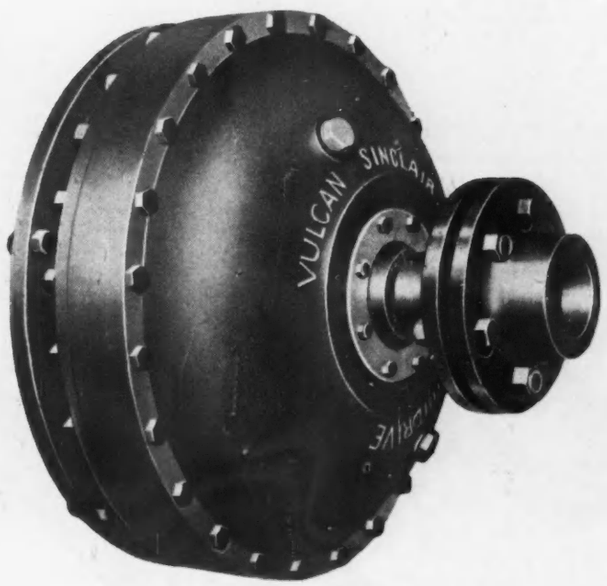

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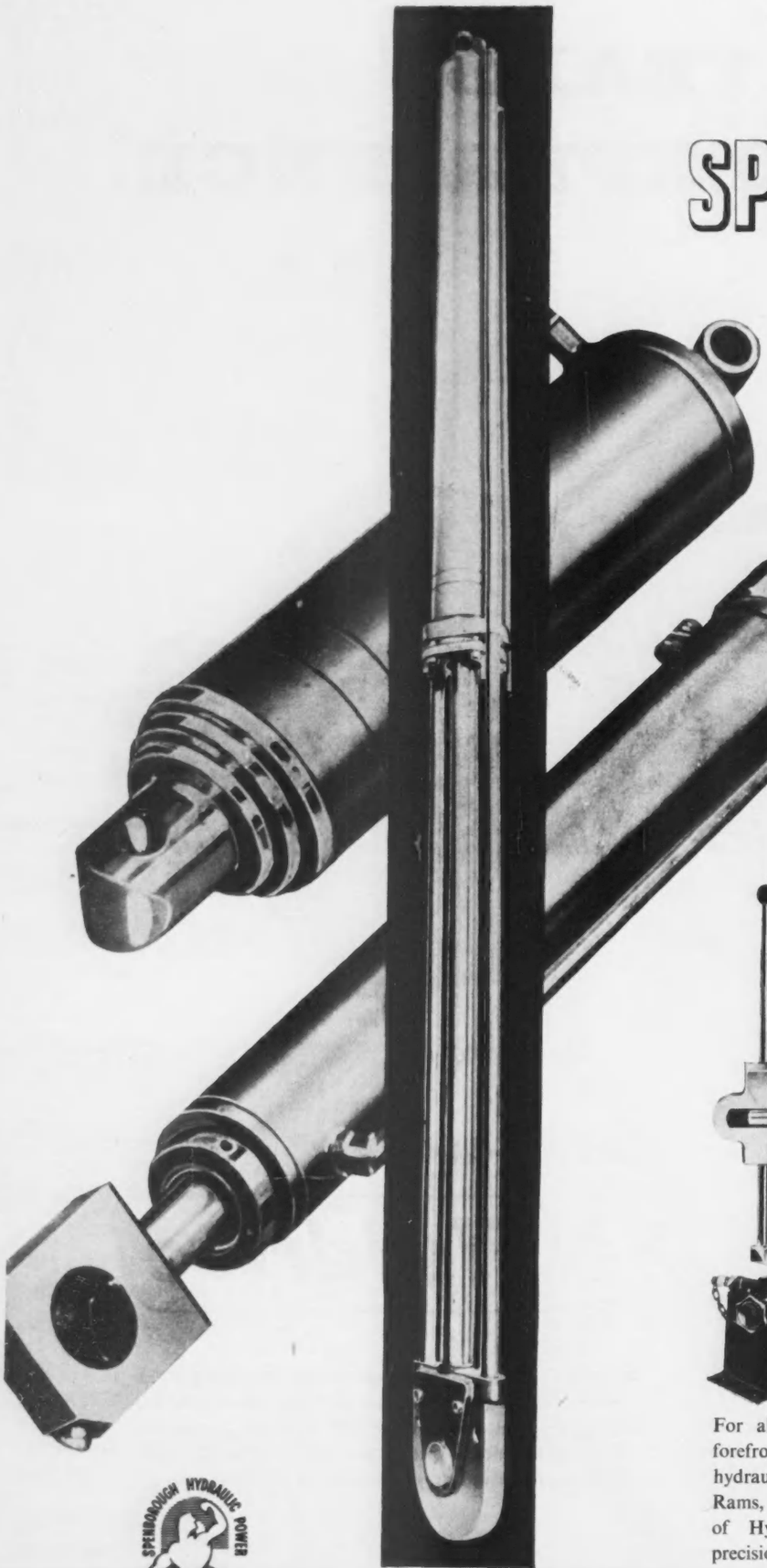

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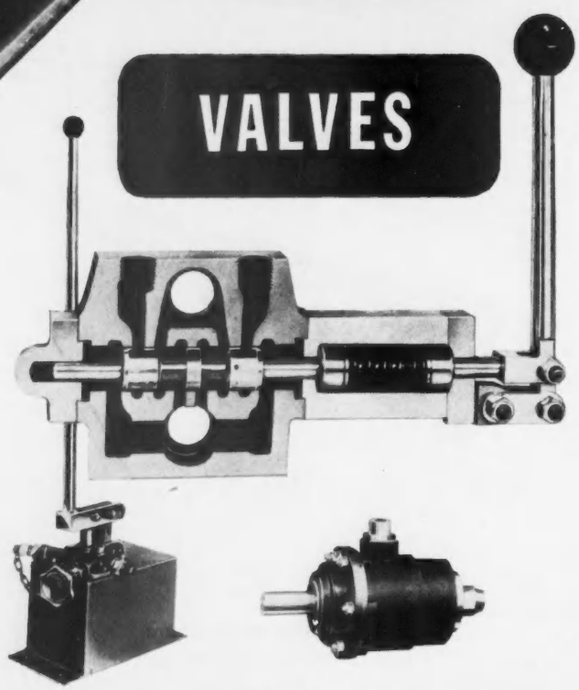

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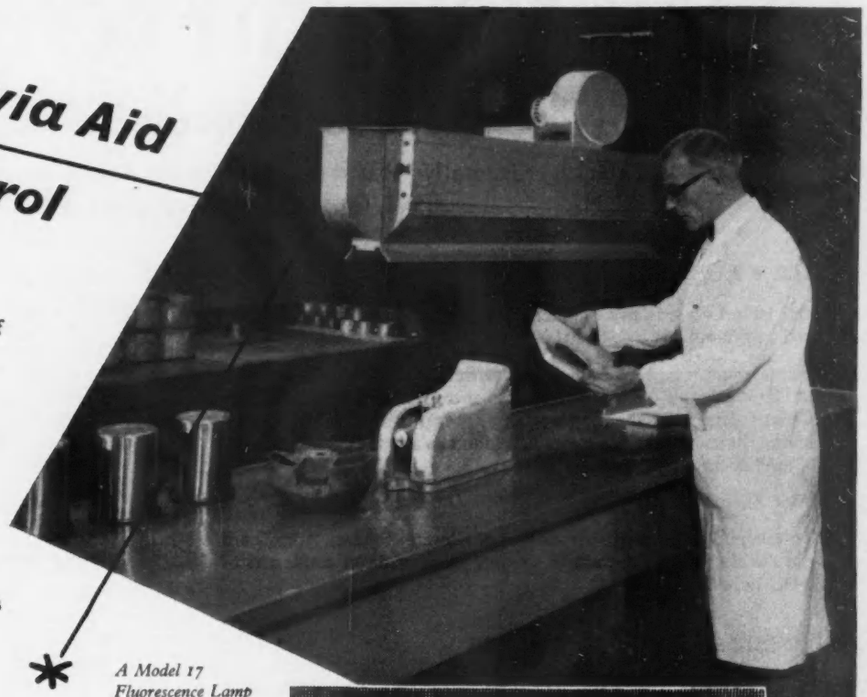
The Hanovia Model 17 Fluorescence Lamp provides the means of non-destructive testing of large engineering components by the use of fluorescent inks. The unit is suspension mounted and is of particular use for crankshaft, steel tube, steel sheet, large forgings and component inspection on a conveyor belt system. In the mining industry the Model 17 is well suited to the detection of mineral in crushed ore. Hanovia inspection lamps are also widely used in the textile, chemical, rubber and electrical industries. Please write for details.



* *A Model 17 Fluorescence Lamp being used to examine castings.*

MODEL 16

Model 16 is a *portable* unit for the detection of cracks and flaws and is used for practically every large engineering and assembly works (including many aircraft companies) in the U.K.

Engelhard Industries Ltd.

Hanovia Lamps Division, Dept. No. T.17/10, Slough, Bucks. Telephone: Burnham 500

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CENTRAL ELECTRICITY GENERATING BOARD

TARIFF FOR BULK SUPPLIES TO AREA BOARDS

fixed by the Central Electricity Generating Board (the Generating Board) pursuant to section 37 (1) of the Electricity Act, 1947, for the year ending 31st March, 1961.

NORMAL KILOWATT CHARGE

£7.2s.0d. (seven pounds two shillings) for each kilowatt of the number ascertained by multiplying by 24,000,000

the maximum number of kilowatts determined by deducting from the **half-hour kilowatt demand** supplied to the Area Board the **half-hour kilowatt demand** of the **special consumers** in the same half-hour and adding the sum of the **nominated firm kilowatts** and the **excess kilowatts** (if any) of the **special consumers**

and dividing the product by

the sum of the said maximum number of kilowatts for each Area Board and the chargeable kilowatts in the year of other direct consumers of the Generating Board.

RESTRICTABLE KILOWATT CHARGE

The above Normal Kilowatt Charge less £3.19s.0d. (three pounds nineteen shillings) for each kilowatt of the sum of each maximum **half-hour kilowatt demand** of **special consumers** less the sum of their **nominated firm kilowatts** and less the sum of their **excess kilowatts** (if any)

For the above purposes—

(i) **"the half-hour kilowatt demand"** means twice the number of kilowatt-hours supplied in any half-hour between 7.0 a.m. and 7.0 p.m. on any Monday, Tuesday, Wednesday, Thursday or Friday, or between 7.0 a.m. and 12.0 noon on any Saturday in the year.

(ii) **"special consumer"** means a consumer of the Area Board who has agreed that (without prejudice to any statutory right which the Area Board may have to discontinue the supply of energy) his kilowatt demand can be restricted by the Generating Board for up to 2 hours on any occasion and up to an aggregate of 50 hours in the year provided that

(a) The supply is afforded to the consumer's premises directly from a generating station or substation of the Generating Board through circuits not used for supplies to other consumers.

(b) The difference between the consumer's maximum **half-hour kilowatt demand** and his **nominated firm kilowatts** shall be not less than 25,000 kilowatts.

(c) Suitable provisions have been made in respect of the costs of connection and the technical arrangements for operation, control, and metering, which may vary with local circumstances, and

(d) Prior agreement has been made between the consumer, the Area Board and the Generating Board in each case.

(iii) **"Nominated firm kilowatts"** means the **half-hour kilowatt demand** which in accordance with the above arrangements the **special consumer** is entitled to make during a period of restriction.

(iv) **"Excess kilowatts"** means the amount by which the **nominated firm kilowatts** is exceeded by twelve times the largest number of kilowatt-hours supplied to the **special consumer** in any five minutes (excepting the first five minutes) during any period commencing when the Generating Board indicate (by a signal or otherwise) that they require his demand to be restricted in accordance with the above arrangements, and ending when the Generating Board indicate that normal supply may be resumed.

RUNNING CHARGE

0.41d. (decimal four one of a penny) for each kilowatt-hour supplied during the year, this charge to be increased or reduced by 0.00055d. (decimal nought nought nought five five of a penny) for each penny (a halfpenny or any greater part of a penny being treated as a penny) by which the fuel cost per ton in the year shall be above or below 60s. (sixty shillings).

For this purpose—

(i) **"Fuel cost per ton"** in any period shall be either

(a) the quotient produced by dividing the aggregate of the product of the **Area fuel cost per ton** in the period and the **number of kilowatt-hours supplied from generation in the Area** in the period and the product of the **residual cost per ton** in the period and **the number of kilowatt-hours imported into the Area** if any in the period by **the number of kilowatt-hours supplied in the Area** in the period; or

(b) **the Area fuel cost per ton ;**
whichever is the less.

(ii) **"The Area"** means the Area of the Area Board taking the supply.

(iii) **"The Area fuel cost per ton"** in any period shall be determined as follows: the total **cost of fuel consumed** in the period at all the Generating Board's stations in **the Area** shall be divided by the total number of tons of **fuel** so consumed and the cost per ton so obtained shall be multiplied by 11,000 and divided by the average gross thermal value of **fuel** so consumed expressed in British thermal units per pound.

(iv) **"Fuel"** shall mean coal, coke and oil fuels but shall not include atomic fuels.

(v) **"The cost of fuel consumed"** shall mean the sums expended for **fuel** consumed plus the cost of any transport, handling preparation or treatment incurred in connection with the delivery of the **fuel** to boiler hoppers or furnaces and in connection with the disposal of the products or residues of combustion, together with the proper proportion of salaries and wages and any contributions for pensions, superannuation and insurance of officers and servants attributable thereto and the amount of any rebate allowed by the suppliers from the price of heavy fuel oil delivered at the Generating Board's stations, such rebate being attributable only to a specific quantity of heavy fuel oil so delivered, less any sums received from the sale of any products or residues of combustion.

(vi) **"The number of kilowatt-hours supplied from generation in the Area"** in any period means the number of kilowatt-hours (being kilowatt-hours generated by the combustion of **fuel**) sent out from all the stations of the Generating Board in **the Area** in the period or **the number of kilowatt-hours supplied in the Area** in the period whichever is the less.

(vii) **"The number of kilowatt-hours supplied in the Area"** in any period shall mean the number of kilowatt-hours supplied in the period by the Generating Board to the relevant Area Board and to other consumers in **the Area.**

(viii) **"The number of kilowatt-hours imported into the Area"** means the amount if any by which **the number of kilowatt-hours supplied in the Area** exceeds **the number of kilowatt-hours supplied from generation in the Area.**

(ix) **"The residual cost per ton"** in any period shall mean the aggregate of—

(A) the quotient produced by dividing the amount by which **the national fuel cost per ton** in the period multiplied by the aggregate of **the number of kilowatt-hours supplied in the Area** of each Area Board in the period exceeds the aggregate of the respective products in the case of each Area Board of (a) **the Area fuel cost per ton** in the period and (b) **the number of kilowatt-hours supplied from generation in the Area** in the period, by the aggregate of the **number of kilowatt-hours imported into the Area** of each Area Board in the period; and

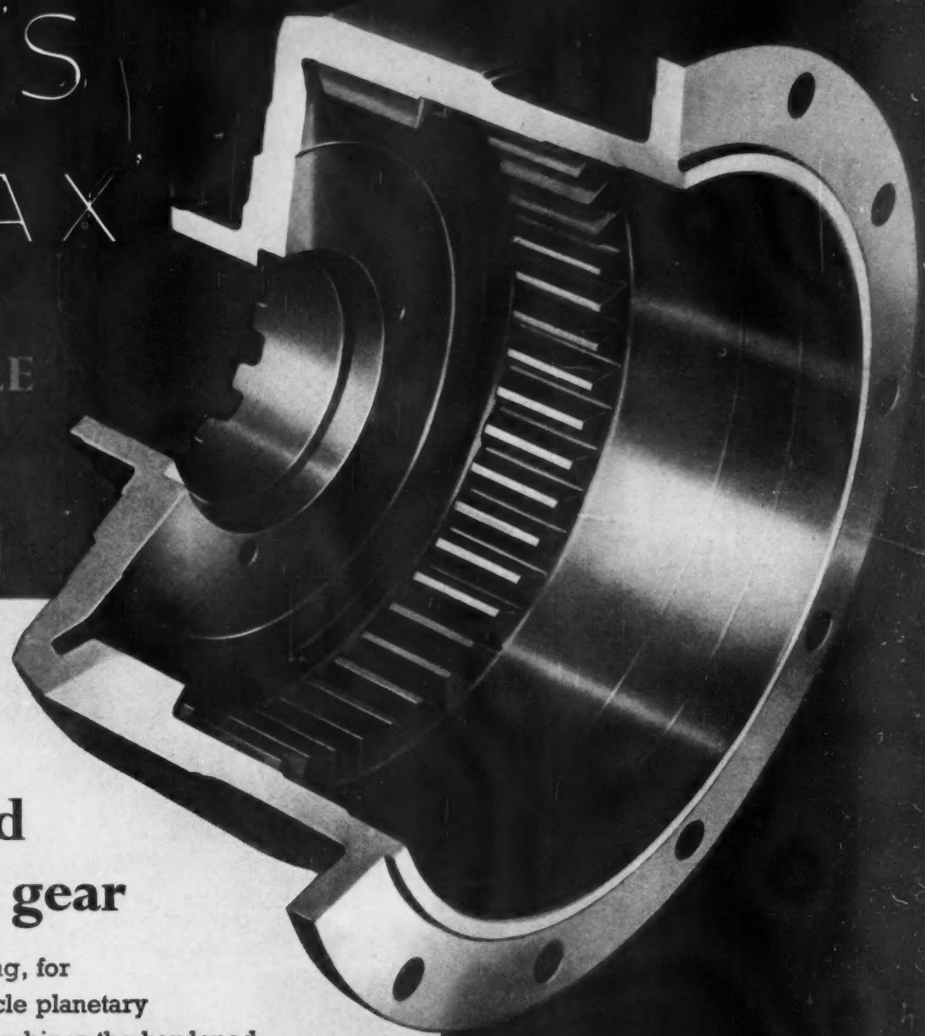
(B) the sum of 6s. (six shillings).

(x) **"The national fuel cost per ton"** in any period shall be determined as follows: the total **cost of fuel consumed** in the period at all the Generating Board's stations shall be divided by the total number of tons of **fuel** so consumed and the cost per ton so obtained shall be multiplied by 11,000 and divided by the average gross thermal value of the **fuel** so consumed expressed in British thermal units per pound.

LEY'S

LEMAX

PEARLITIC
MALLEABLE
CASTINGS



Flame-hardened internal gear

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The casting, which is 11 inches diameter and weighs 38 lb., meets the following specification:

Gear-teeth: flame-hardened.
Journal: induction hardened.
Min. tensile strength: 100,000 P.S.I.
Min. yield strength: 80,000 P.S.I.
Min. elongation in 2" : 2%.

Registered Trade Marks: 'Black Heart' 'Ley's' 'Lepax' 'Lemax'

LEY'S MALLEABLE CASTINGS COMPANY LIMITED
DERBY, ENGLAND. *Telephone:* Derby 45671

LEY'S

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CENTRAL ELECTRICITY GENERATING BOARD

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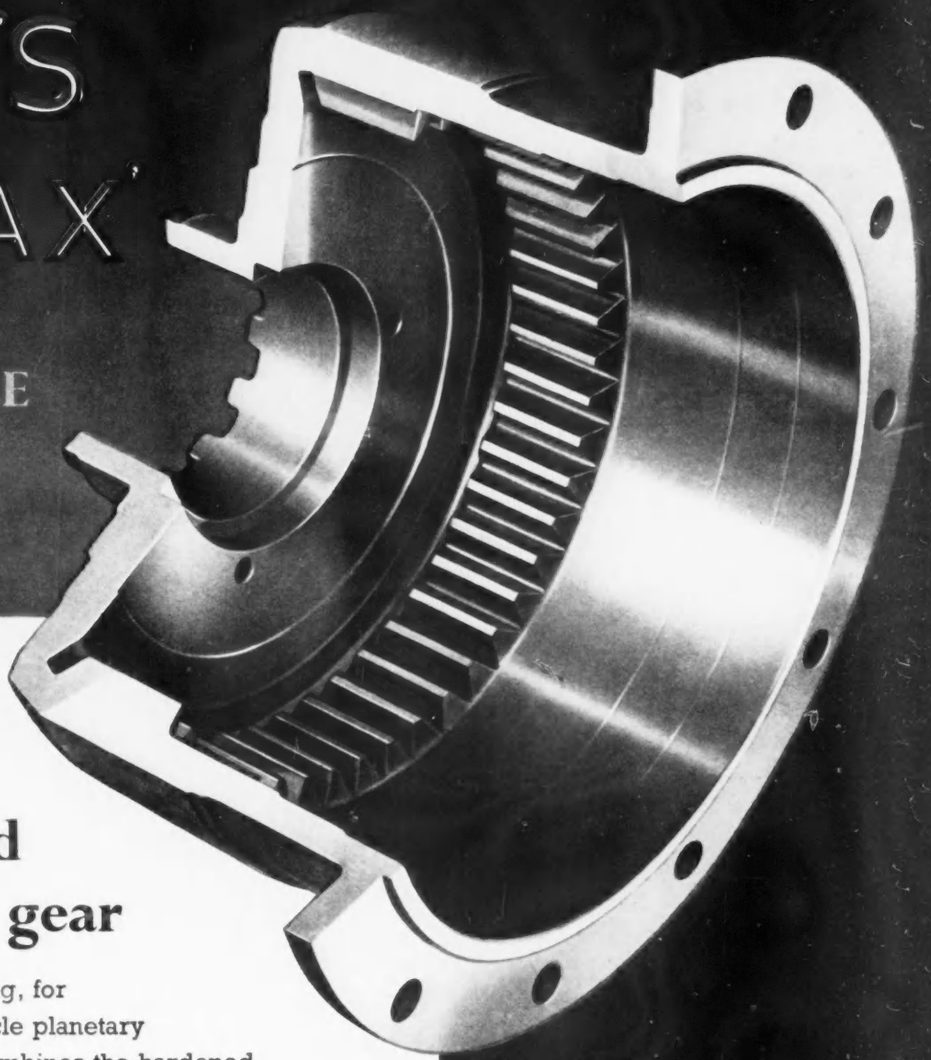
LEY'S 'LEMAX'

PEARLITIC MALLEABLE CASTINGS



Flame-hardened internal gear

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The casting, which is 11 inches diameter and weighs 38 lb., meets the following specification:

Gear-teeth: flame-hardened.
Journal: induction hardened.
Min. tensile strength: 100,000 P.S.I.
Min. yield strength: 80,000 P.S.I.
Min. elongation in 2" : 2%.

Registered Trade Marks: 'Black Heart' 'Ley's' 'Lepaz' 'Lemax'

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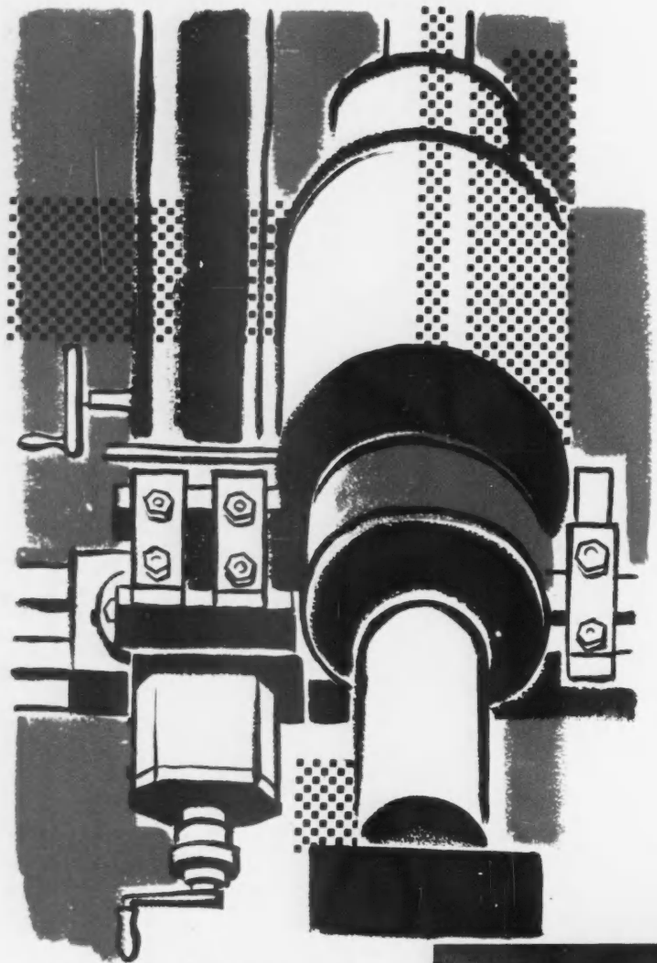

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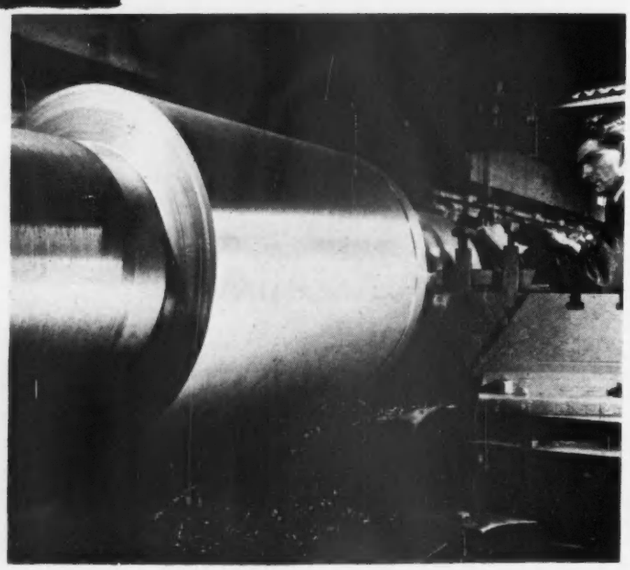

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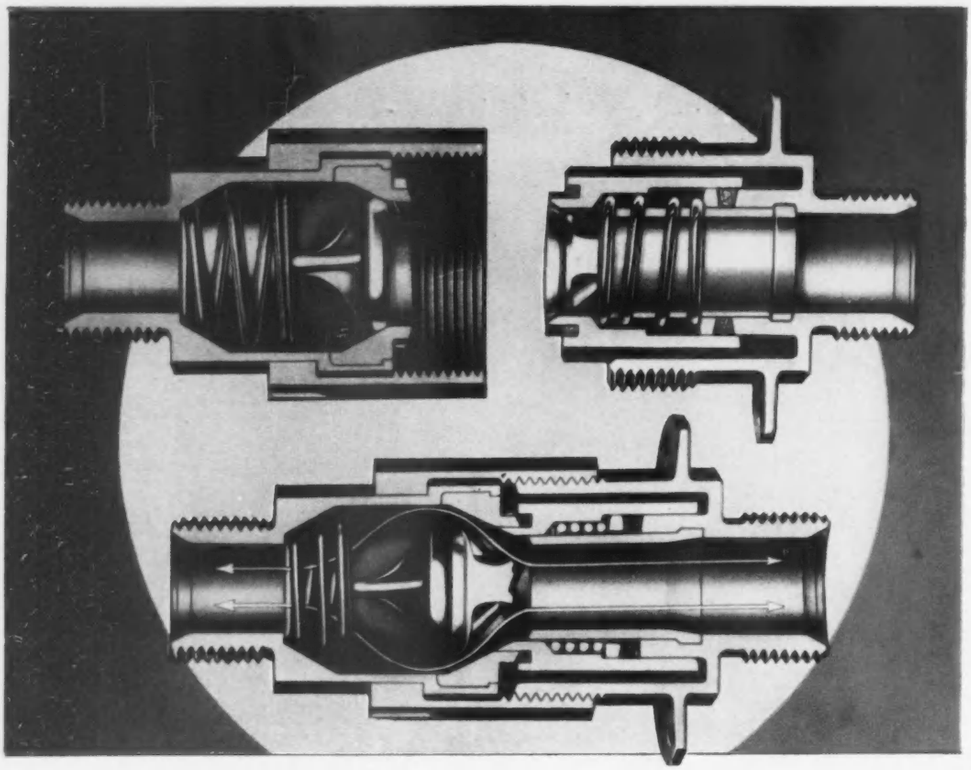

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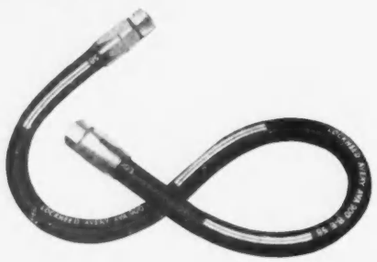

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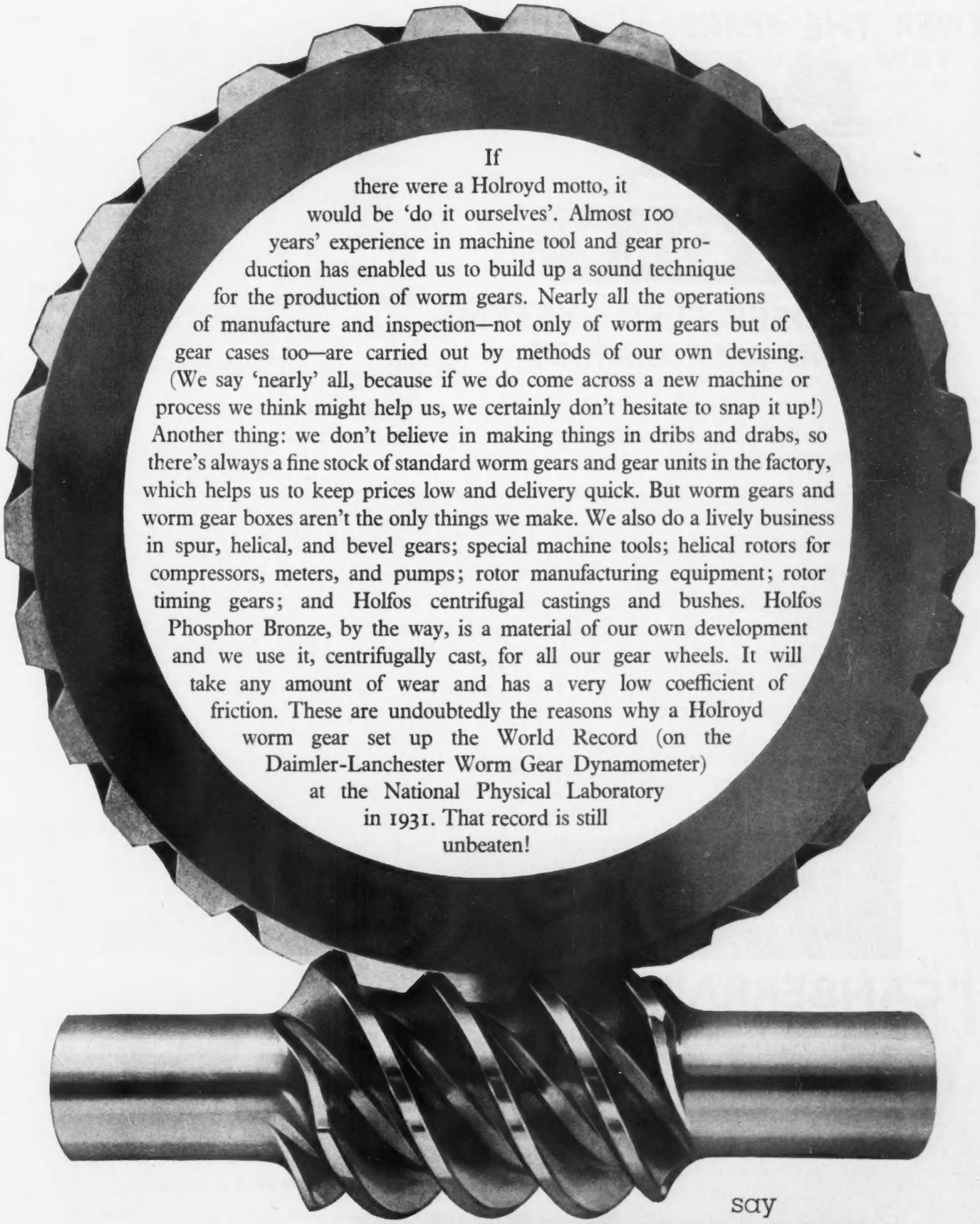

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years' experience in machine tool and gear pro-
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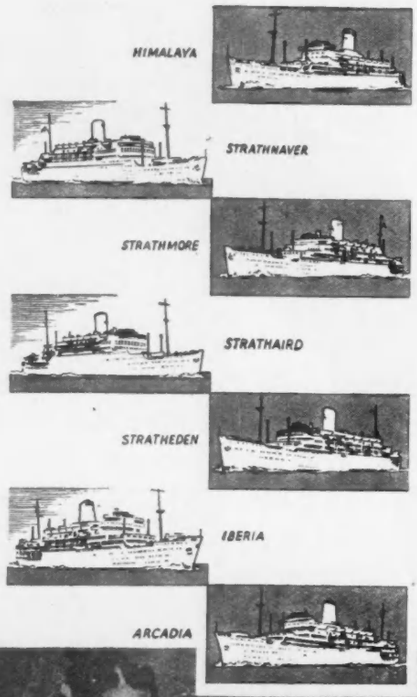

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is extensively Weir equipped

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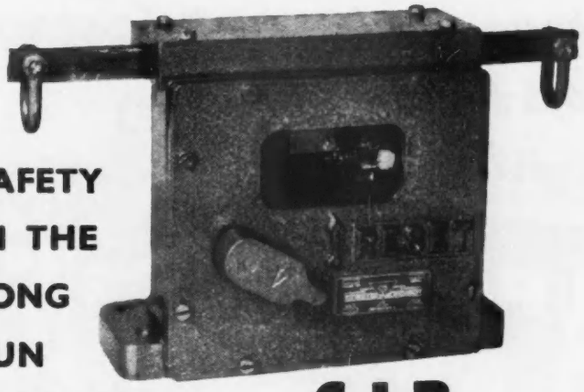

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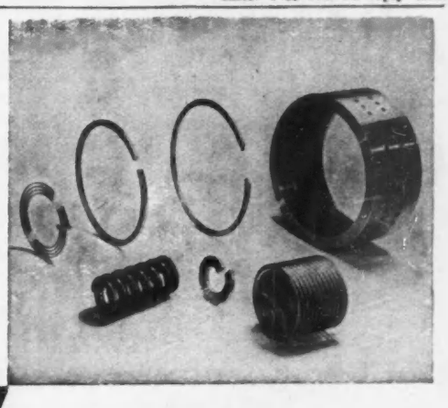

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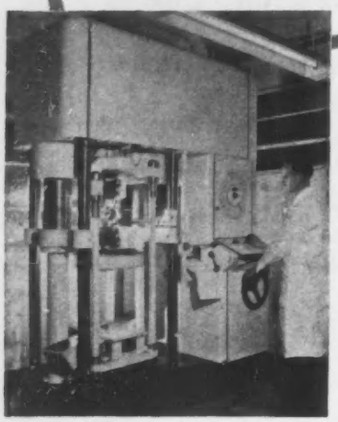

A Denison Model T42B Universal Testing Machine at the laboratories of John Holroyd & Co. Ltd., Holfos Works, Rochdale. Photograph shows the Patent Mechanical Extensometer being used.

These multi-capacity Self-Indicating Universal Testing Machines embody many outstanding features. The load is accurately measured through knife-edged weighing levers and all controls are conveniently grouped so that operators find these machines a pleasure to handle.

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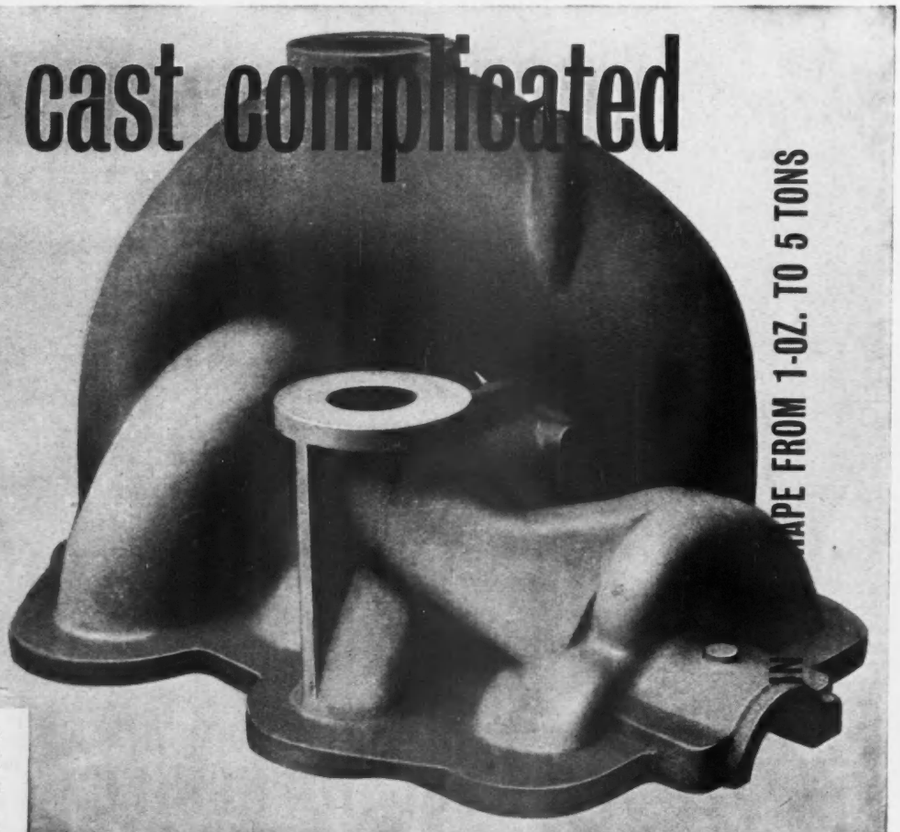

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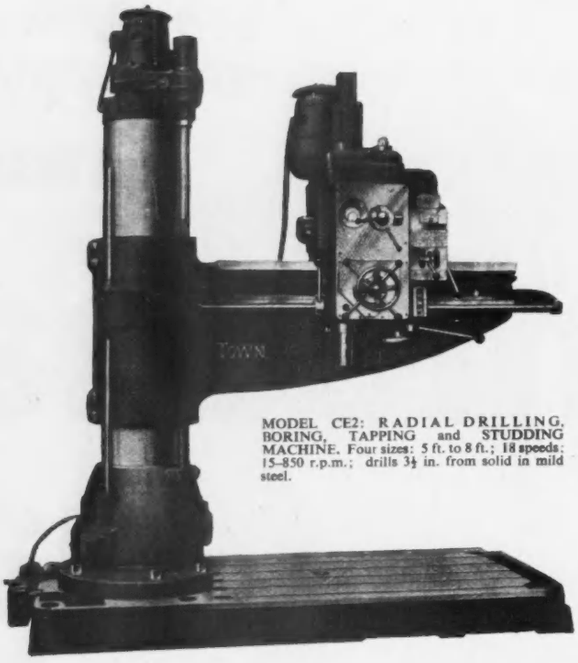

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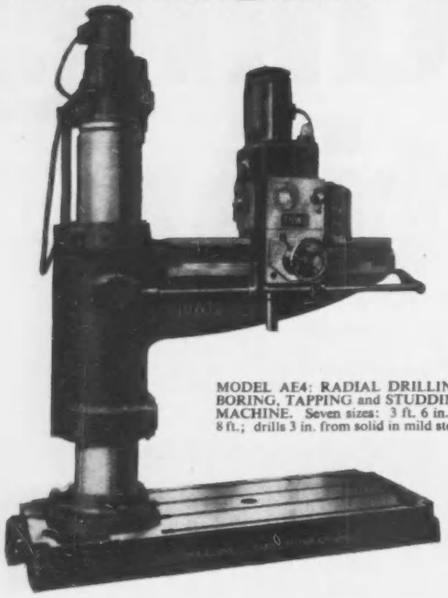

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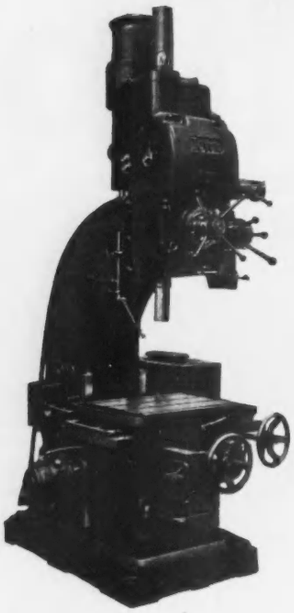

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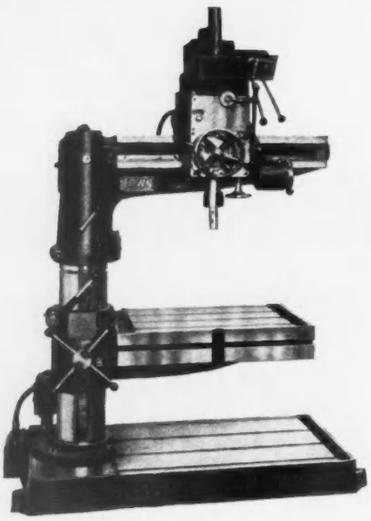
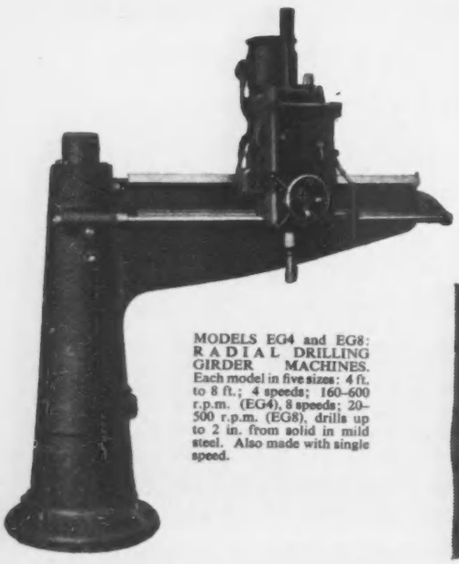


MODEL AE5: RADIAL DRILLING, TAPPING and STUDDING MACHINE. 42 in.; drills 1½ in. from solid in mild steel or 1½ in. in cast iron.



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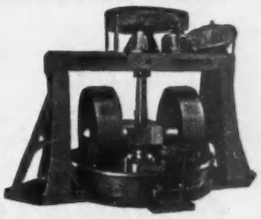

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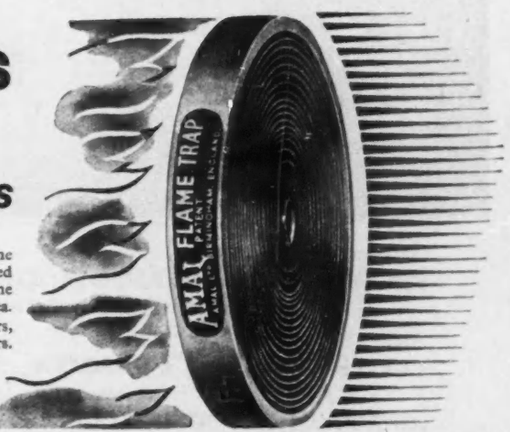

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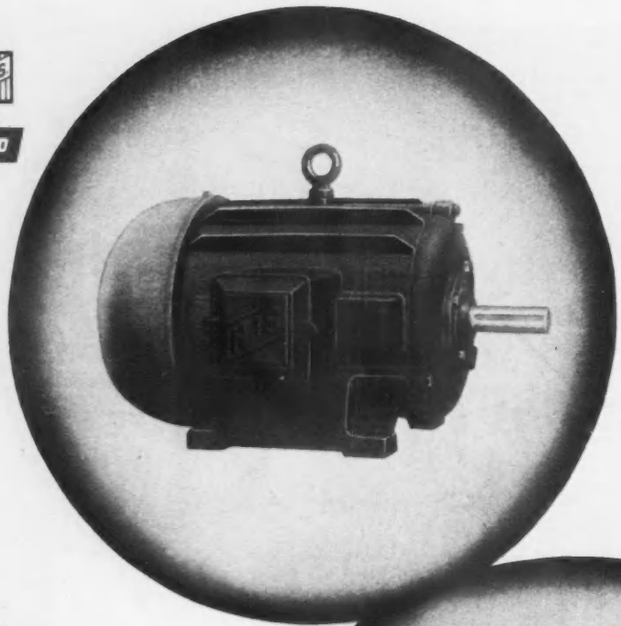

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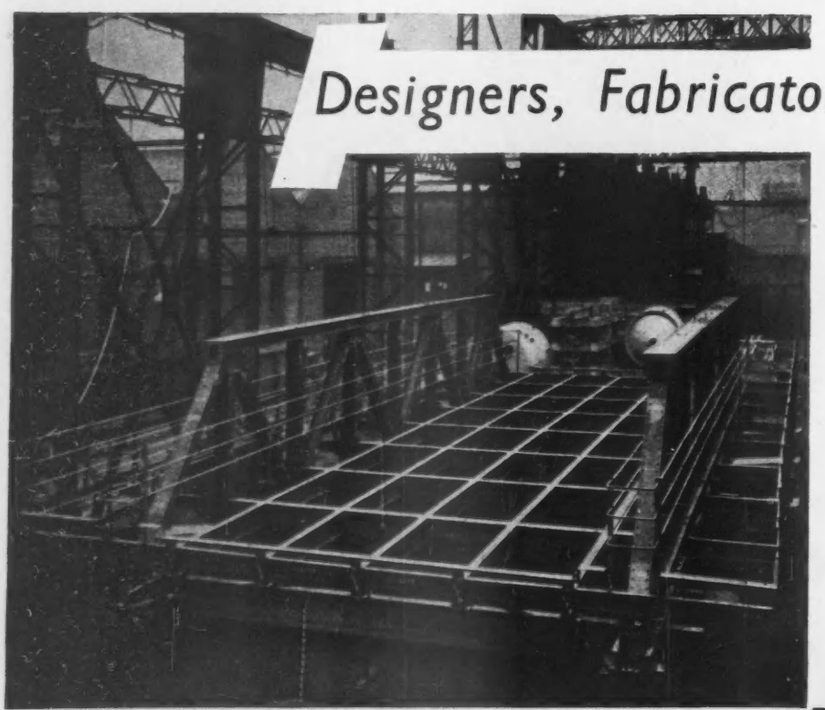

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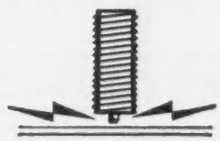

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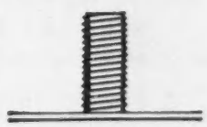

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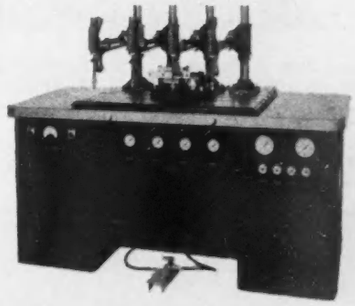

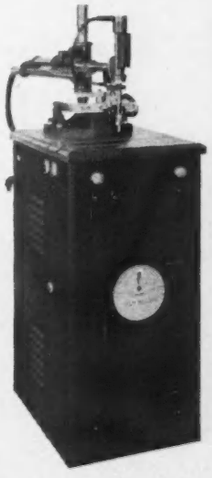

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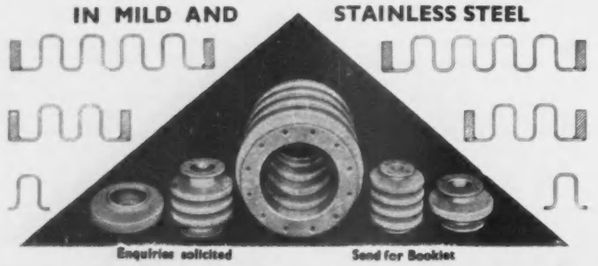

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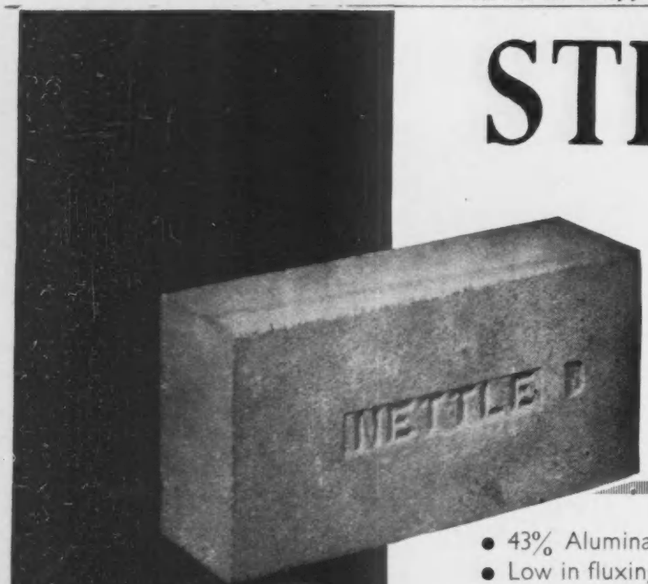

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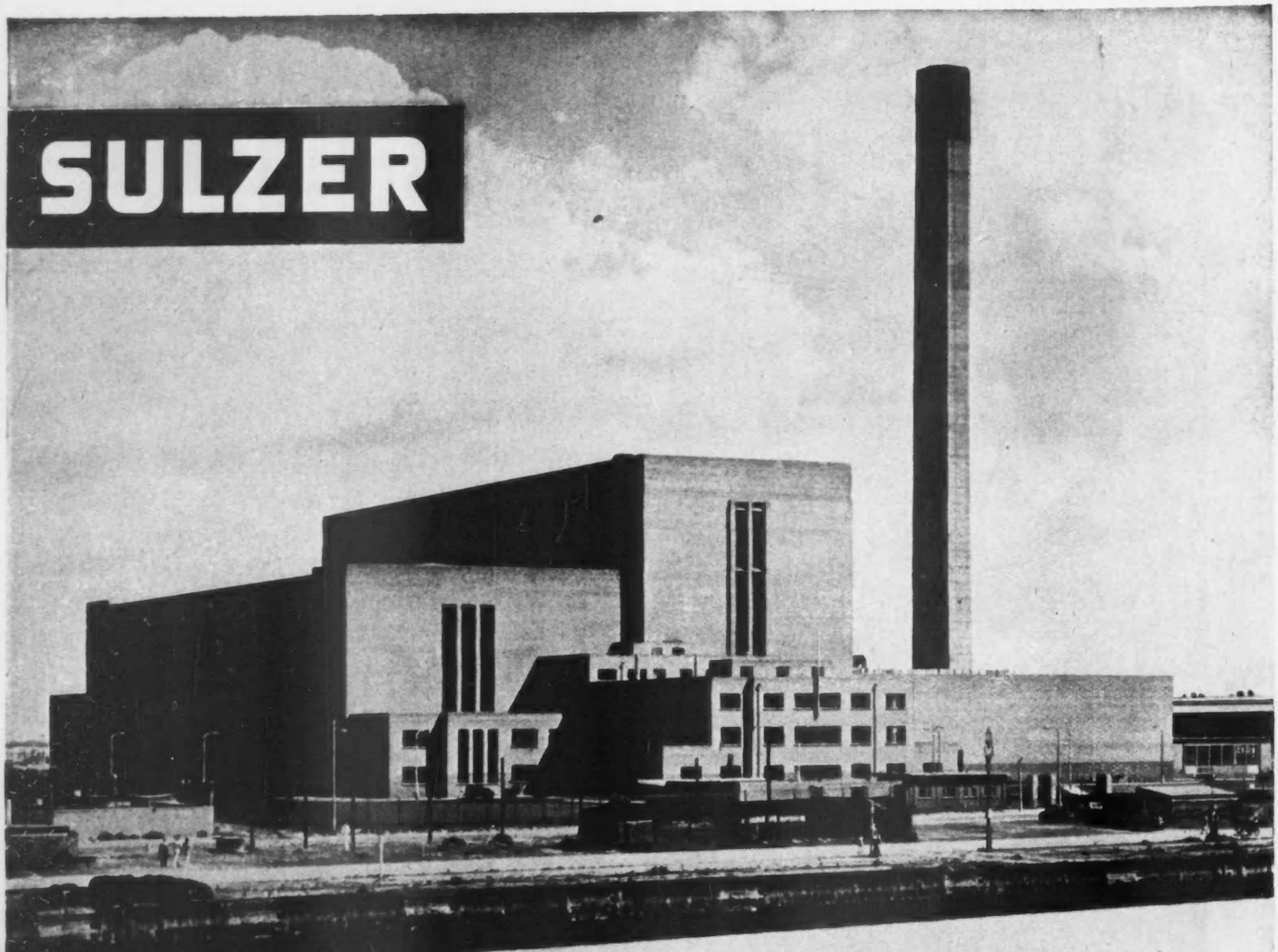

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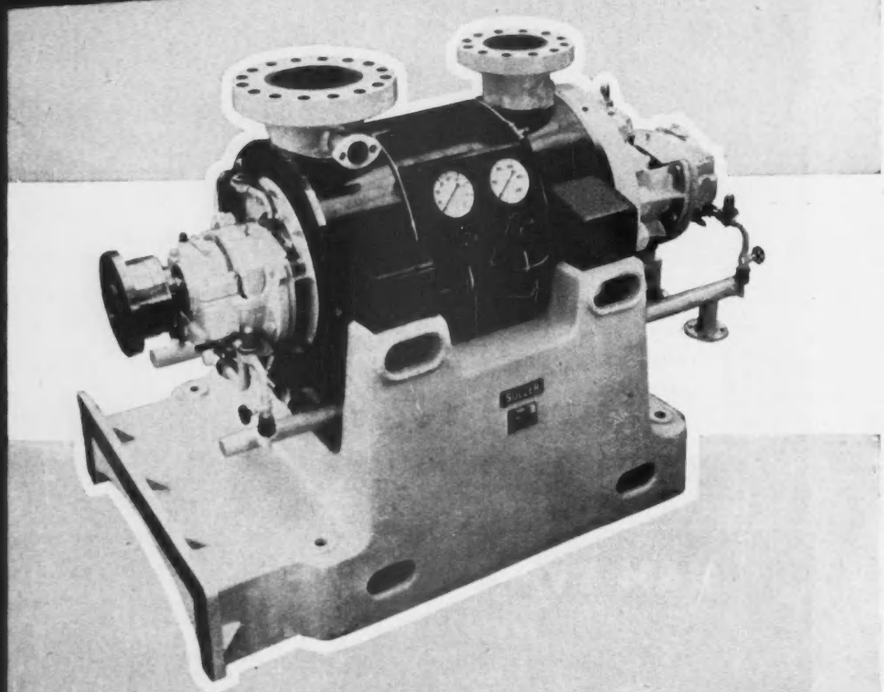

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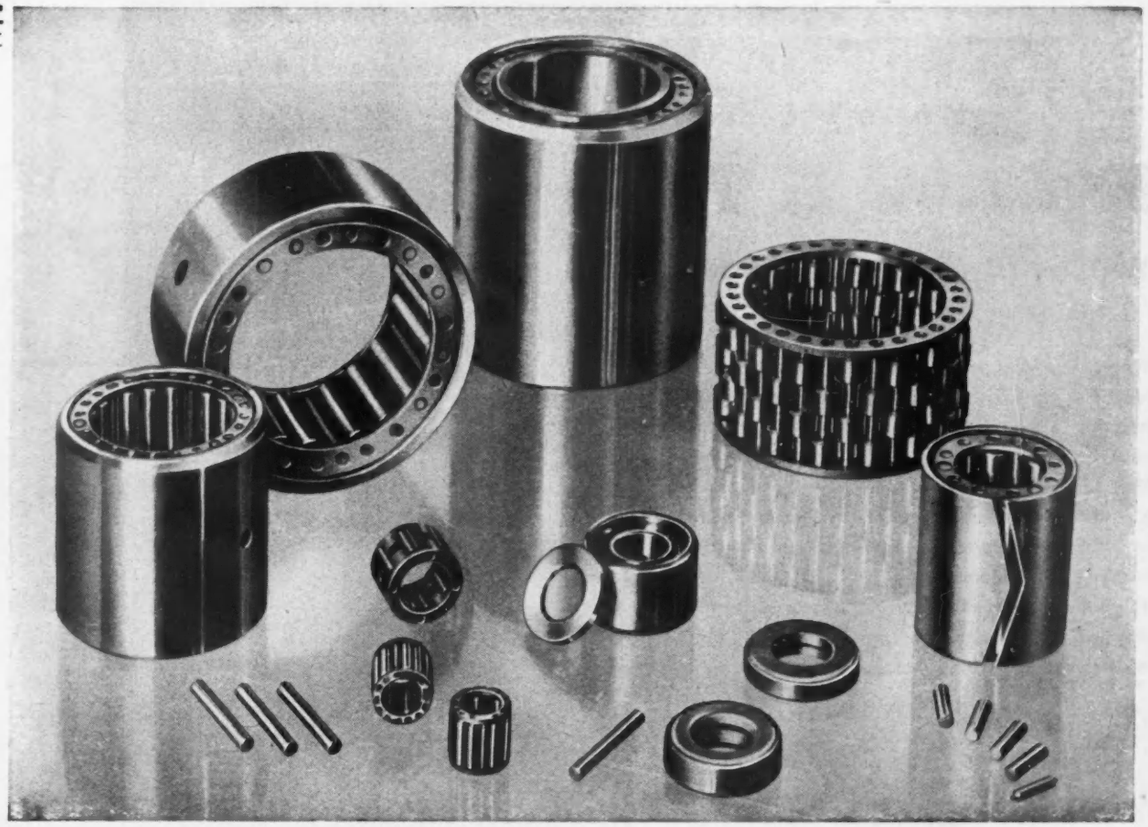

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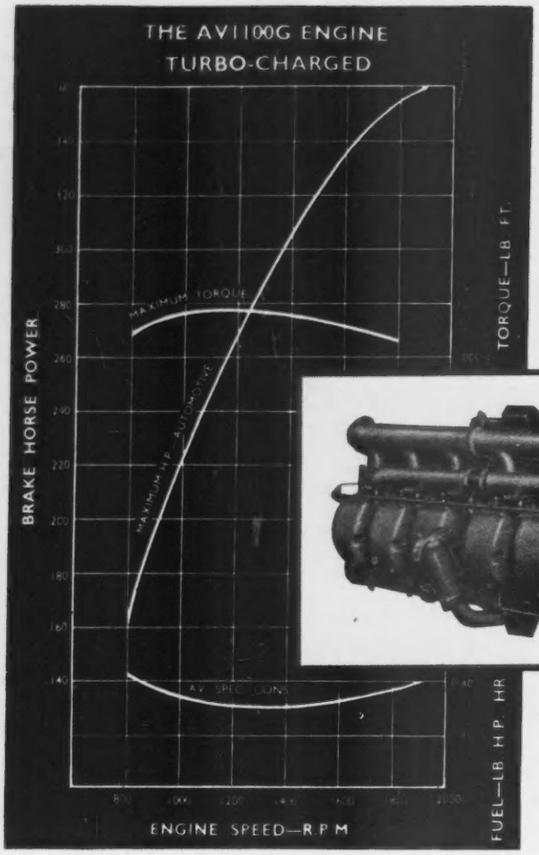
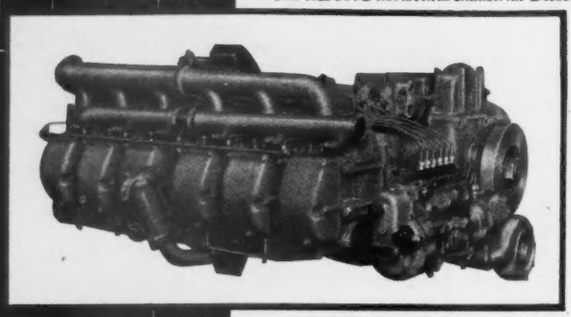
Every A.E.C. diesel has behind it the experience of nearly 30 years in diesel design and production, and a world-wide service and spares organisation that never sleeps.



The AH100G horizontal Industrial Diesel



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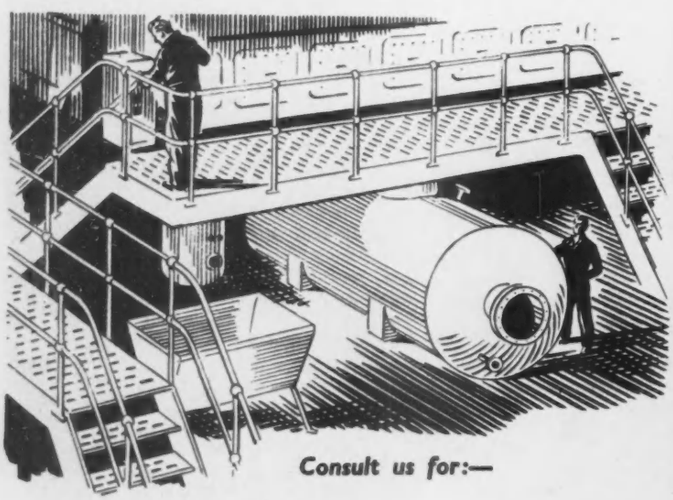

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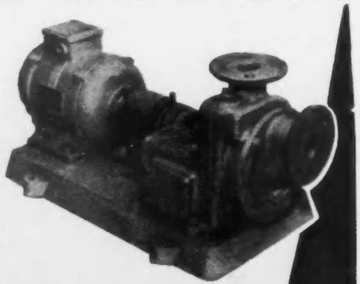

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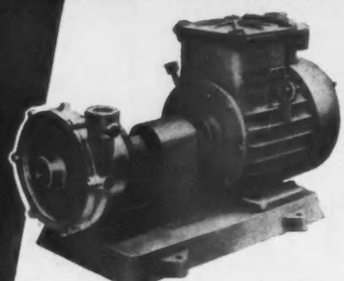
FOR CORROSIVE LIQUIDS ACIDS CHEMICAL SOLUTIONS



1" centrifugal pump fitted with mechanical seal and coupled to flame proof motor. Other types available where gland packing is specified. Pump sizes; up to 1½" screwed BSPT, and 2" flanged BSS'D'

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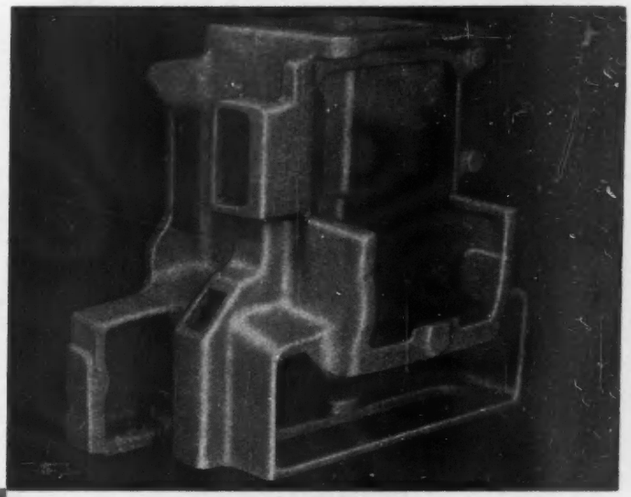

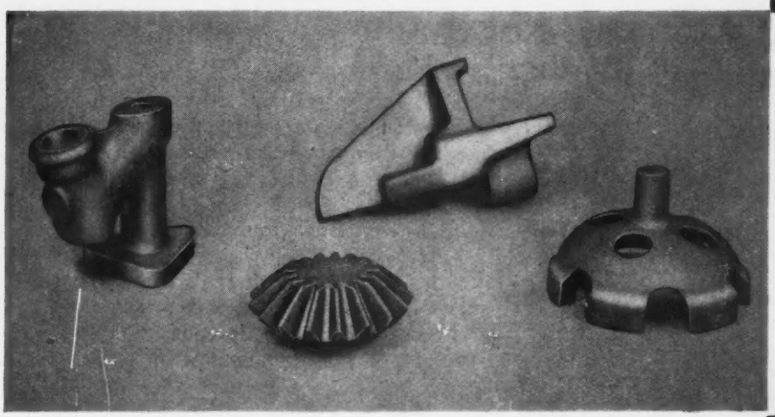

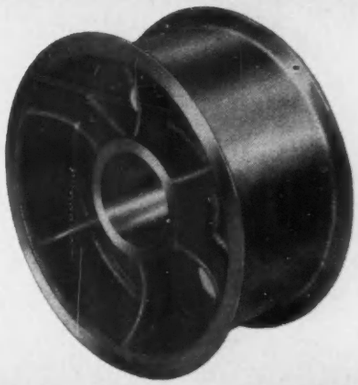

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With this type of pumping unit the variation in power demand between zero and maximum discharge is comparatively small, thus minimising the risk of overloading the motor.

The pump can be designed to pass large solids and is particularly suitable for sewage or storm-water duties. For very large quantities the volute may be made of concrete ; this results in lower overall cost.

34 31-in. Allen vertical, single-suction, single-stage, mixed-flow volute pump and 140-h.p. totally-enclosed motor with an Allen-Stoeckicht epicyclic speed-reducing gear incorporated in the motor pedestal.
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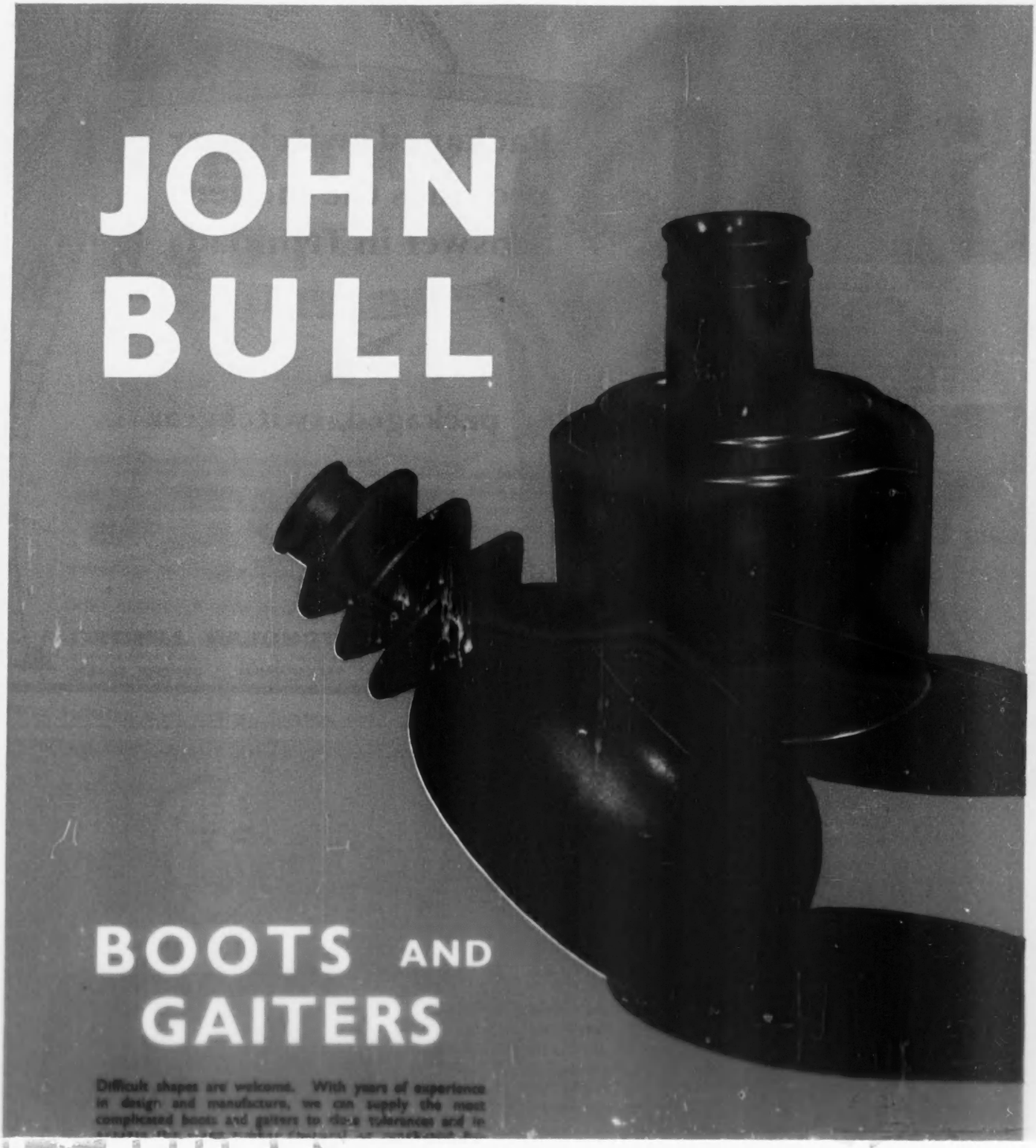

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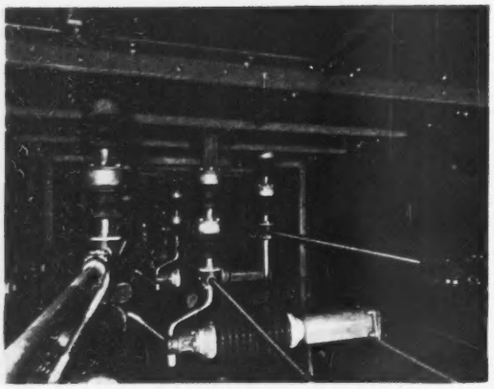
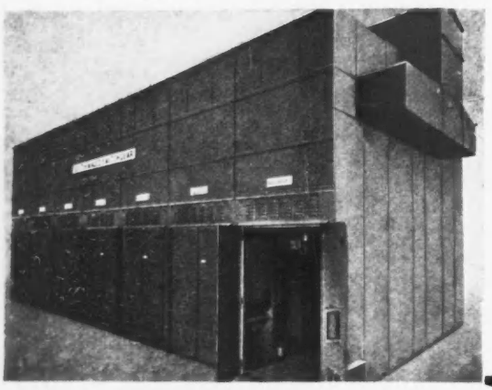


above: the busbar chamber of a 33kV type UH1 switchboard.

below: a 7-panel duplicate busbar, air-insulated switchboard for 33kV, 1 000MVA, service, with motor wound spring operated mechanism, supplied to The Electricity Commission, Port of Spain, Trinidad.



Packaged switchgear provides the modern answer in Trinidad

SWS

for packaged switchgear

Type UH1 metalclad, package switchgear, for 33kV outdoor service, has many attractive features which include:- remarkably small space requirements; the very minimum of preparatory site work; speedy and simple erection and installation; 'in situ' inspection unaffected by weather conditions, and competitive initial cost. This air-insulated unit, either single or duplicate busbar, has been fully tested and certified and complies in every respect with BS116:1952.
Ratings: 33kV up to 1 000MVA and currents up to 2 000A
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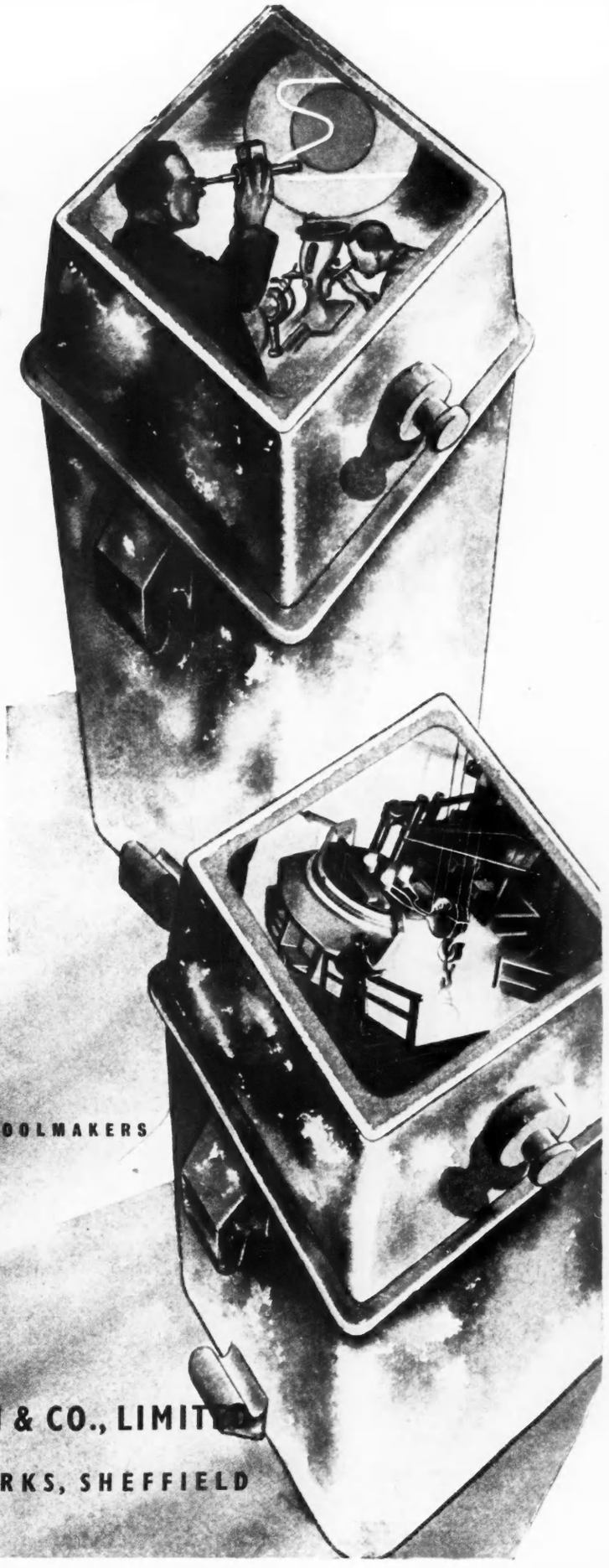

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US GIANT CONVEYOR BELTING for Britain's Power Programme

A substantial addition to power capacity has been completed at Portishead Power Station —the largest in South West England.

BELTS SUPPLIED BY NORTH BRITISH

Illustrated here are some of the 36" and 42" wide U.S. 'GIANT' belts which feed coal at 400 tons per hour from wharf-side to stock pile or boiler bunkers. Joints were vulcanised in situ by one of our mobile crews. They are shown here closing the press on number 3 conveyor.

Photographs by courtesy of Spencer (Melksham) Ltd. and the C.E.G.B.

Please write for full details. Our experts are always available to help you with your particular conveying problems.

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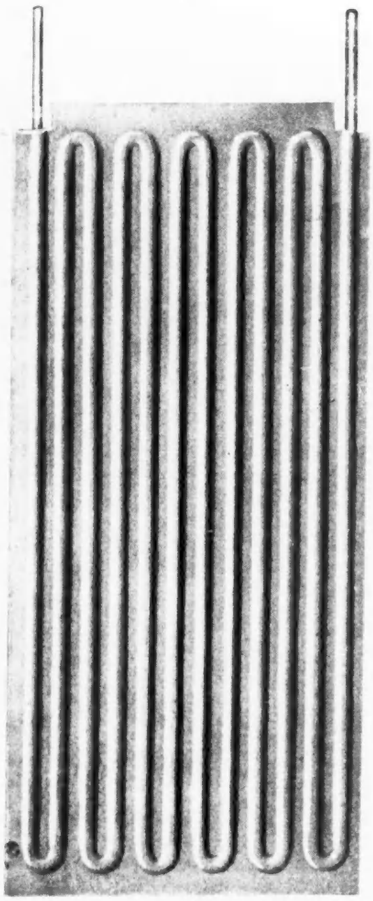
HAVE YOU A HEAT EXCHANGE PROBLEM?



Widely used in the refrigeration industry, Samuel White embossed heat exchange plates have solved many difficult problems in the chemical and engineering industries. They are normally made in mild steel and heavily sprayed with zinc, but are also produced in stainless steel. Single embossed plates with one flat side are available or double embossed plates which provide a larger cross-section area for the liquid or gas circuit.

Brief Technical Details: Sizes: Lengths up to 10ft. Width: Maximum: 36". Circuits: One circuit per plate or to suit requirements.

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0·1964 Sq. In. Single embossed.
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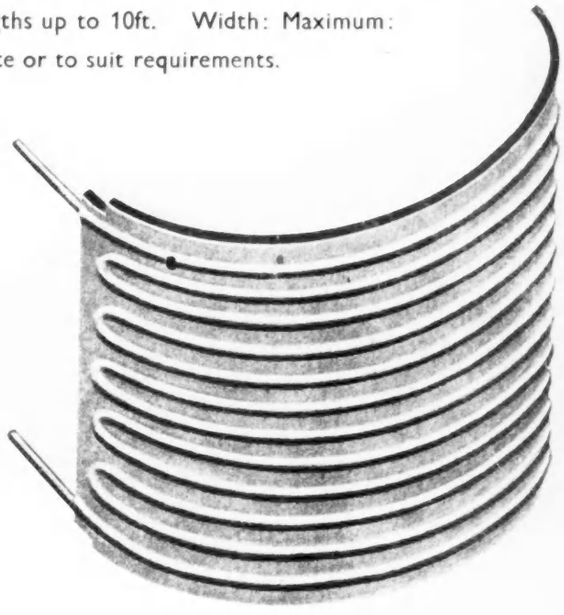

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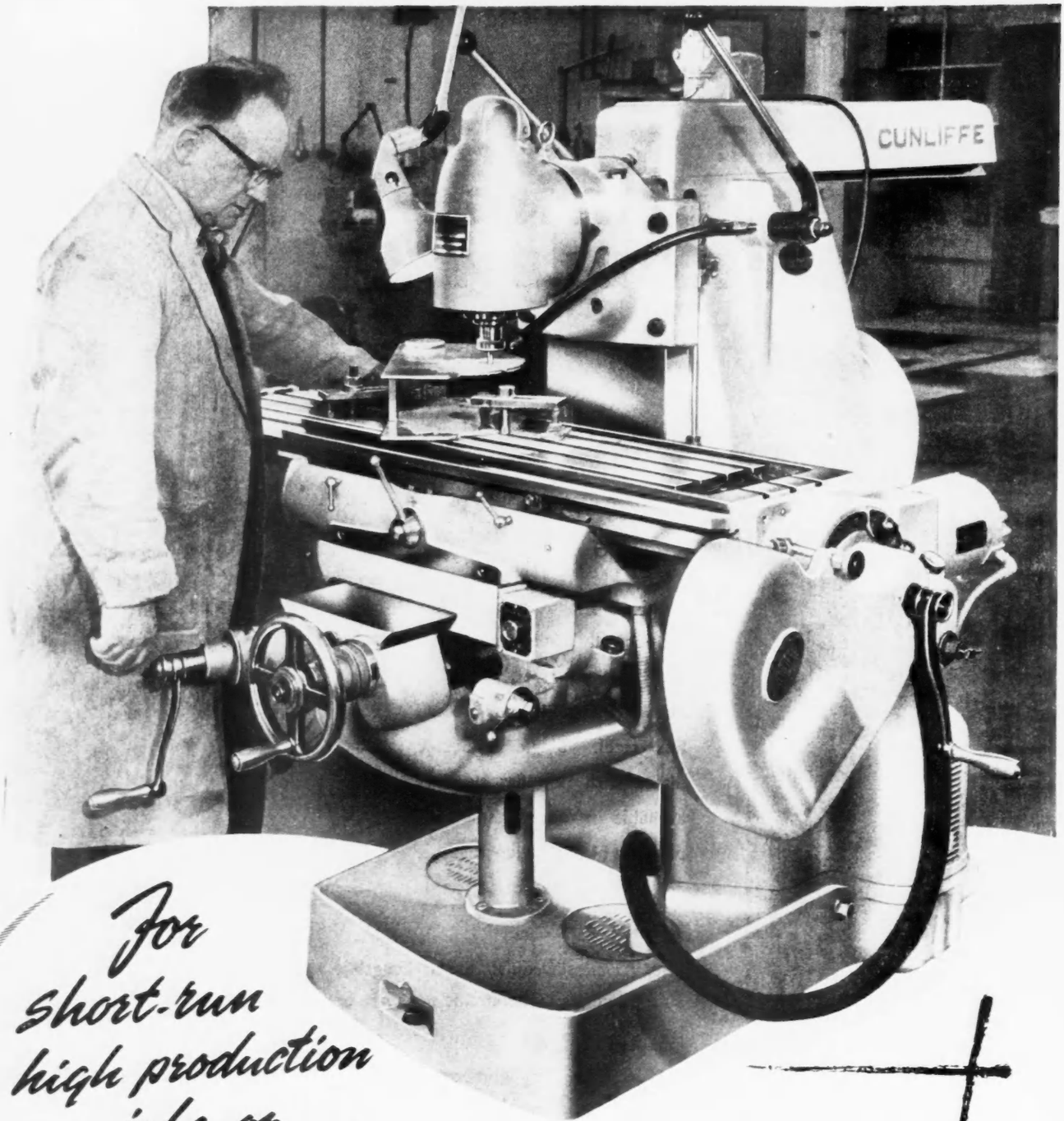

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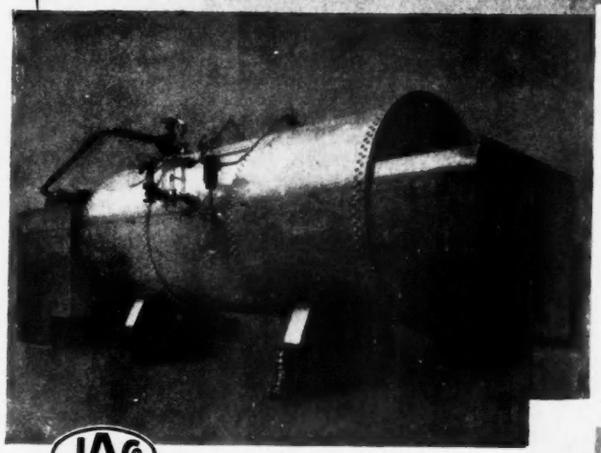
JOSEPH ADAMSON
Waste Heat Boilers

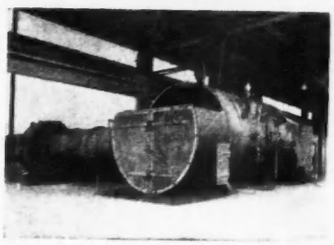


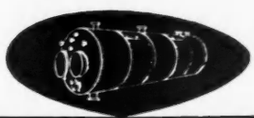
JAC

The Joseph Adamson Waste Heat Boiler is designed to make efficient use of the waste gases leaving open-hearth furnaces, reheating furnaces, soaking pits, gas retorts, etc.

The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

A feature of Joseph Adamson Waste Heat Boilers is that a special cleaning device can be provided in the outlet chamber to allow the tubes to be cleaned while the boiler is at work.





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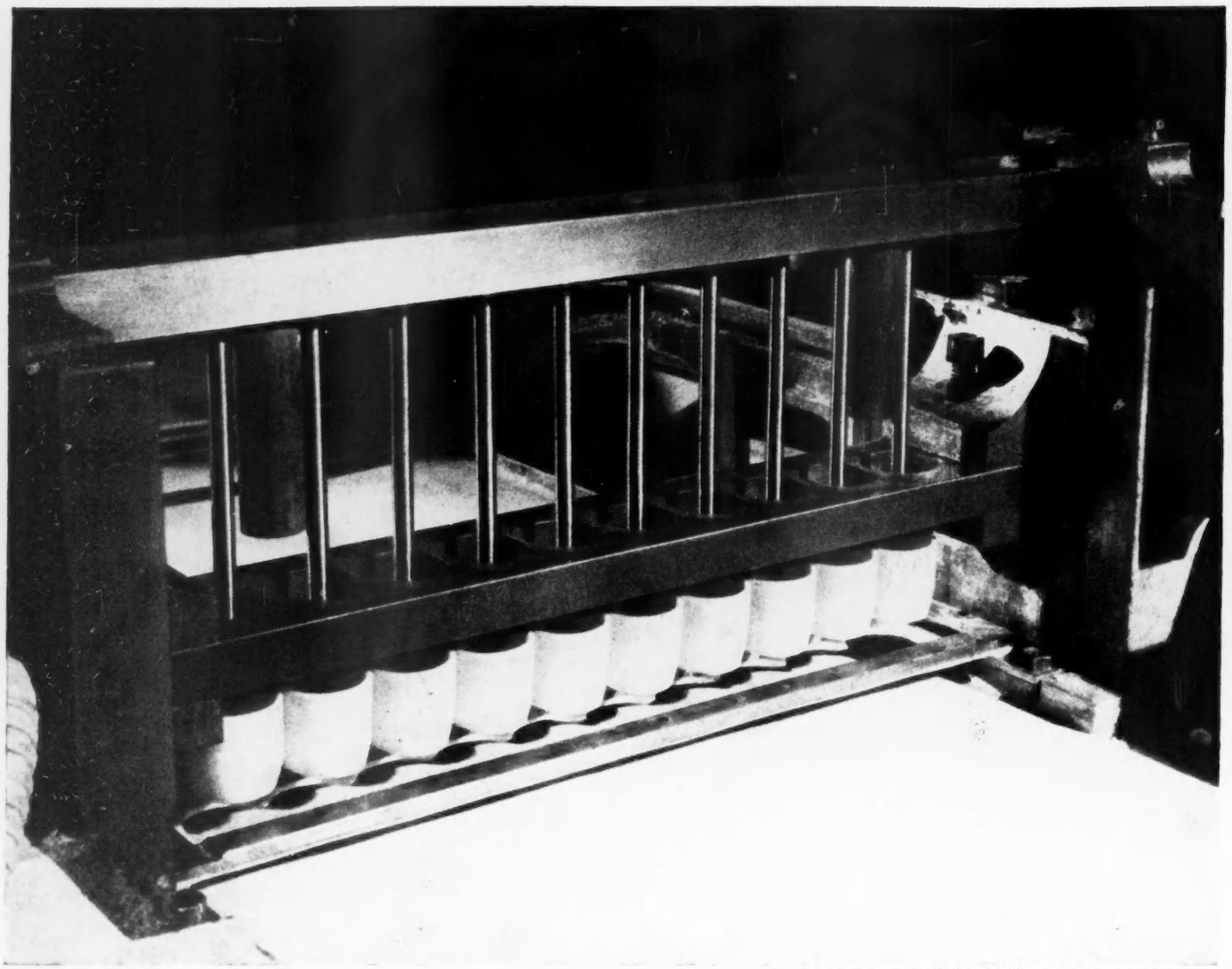
'FLUON' INCREASES PRODUCTION EFFICIENCY IN INDUSTRY

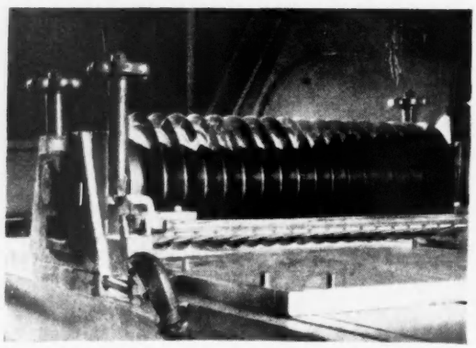


Marzipan centre cutting machine has solid 'Fluon' p.t.f.e. coating on cutters, base plate and release plungers. The work was done by Crane Packing Ltd., Slough, for John Mackintosh and Sons Limited, Norwich.

Non-stick surface makes 'Fluon' ideal for use in marzipan cutting machine

MARZIPAN cutting machines at the Caley Works of John Mackintosh and Sons Ltd., Norwich, always maintain an even flow of production. With a product like marzipan, this is not usually an easy thing to achieve. Marzipan tends to stick to metal surfaces of a machine—on cutting blades and plates, for instance — which means that automatic handling of marzipan is uneconomical. Crane Packing Ltd., Slough, have used 'Fluon' p.t.f.e. dispersion and solid 'Fluon' p.t.f.e. to coat cutters, the rotary cutters, the base plate and the release plungers because of the excellent non-stick properties of 'Fluon' p.t.f.e. This enabled John Mackintosh and Sons Ltd. to change over to automatic handling of marzipan.

As well as having a non-stick surface, 'Fluon' is invaluable on a confectionery machine because it will not taint food in any way. 'Fluon' is a tough, flexible material, is extremely long-lasting and has an outstanding range of properties which commend it for use throughout modern industry.



Crane Packing Ltd., Slough, used 'Fluon' p.t.f.e. dispersion to coat the blades of the rotary cutter and used solid 'Fluon' p.t.f.e. strips on the base plate to prevent marzipan sticking to the automatic cutting machine in Caley Works, John Mackintosh and Sons Ltd.

'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

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Two halves bolted together.

This method of construction supersedes the conventional casting for spur wheels—patterns are not required, and the total elimination of distortion means no rejects. The cost is lower, delivery is faster.

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for Machine Tools, Cranes, Mechanical Handling Equipment, etc.

Extensively used by Butters Bros. in heavy cranes.

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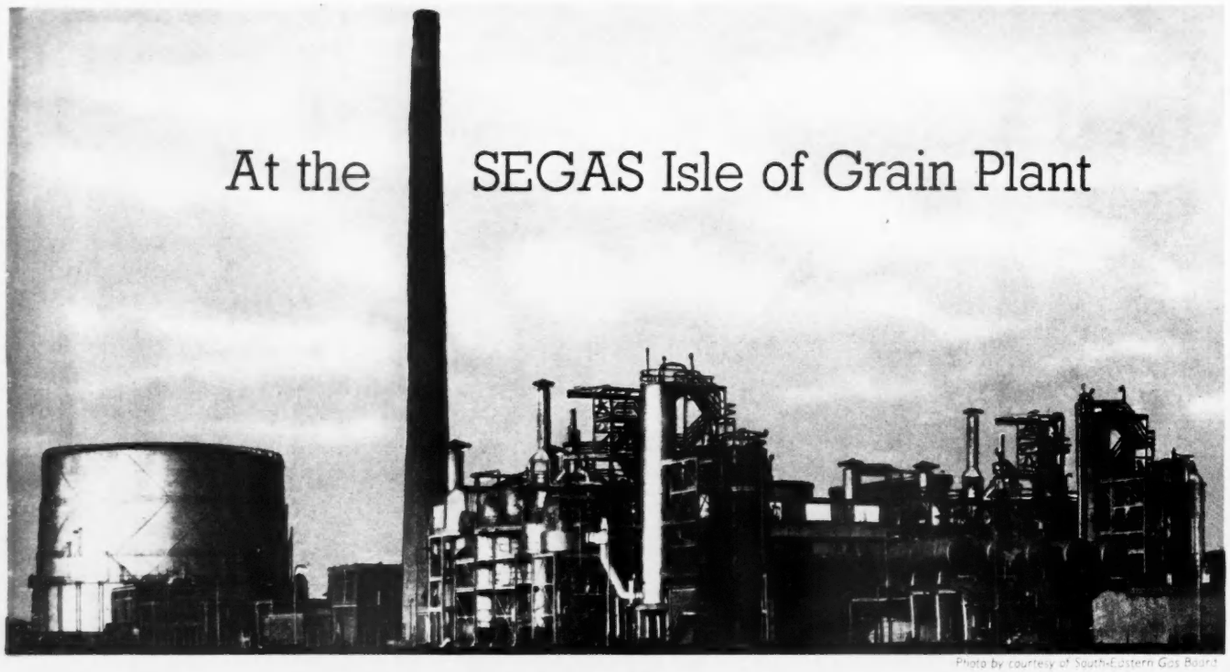
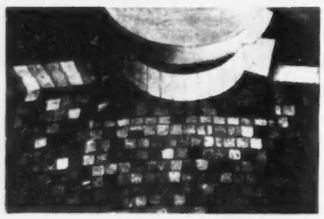


Photo by courtesy of South-Eastern Gas Board

R.B.HILTON installed the refractory linings

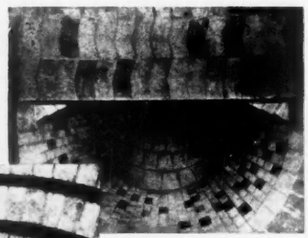


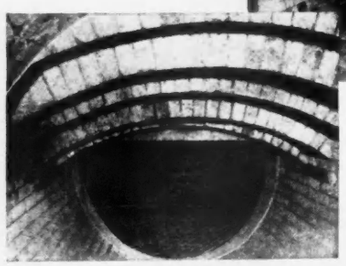
Access hole blocks

Gas from oil at the new Segas Isle of Grain plant is the latest development in British fuel production. A high standard of refractory brickwork is called for in the lining of these ducts and the installation of the arches and domes. Both workmanship and materials must be of the highest quality.

R. B. Hilton Limited carried out the work using materials supplied by General Refractories Ltd. A team of experienced craftsmen worked under the supervision of the Area Manager and the personal scrutiny of one of the company's directors.

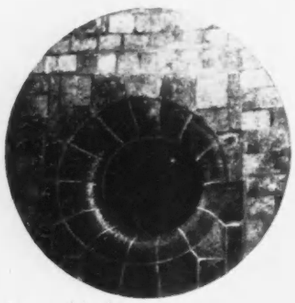
Further details of Hilton's services will gladly be provided on request.





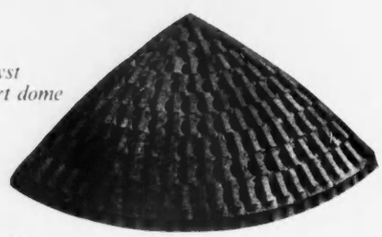
"V" Block Arch blocks

Stepped arches



Burner block

Catalyst support dome



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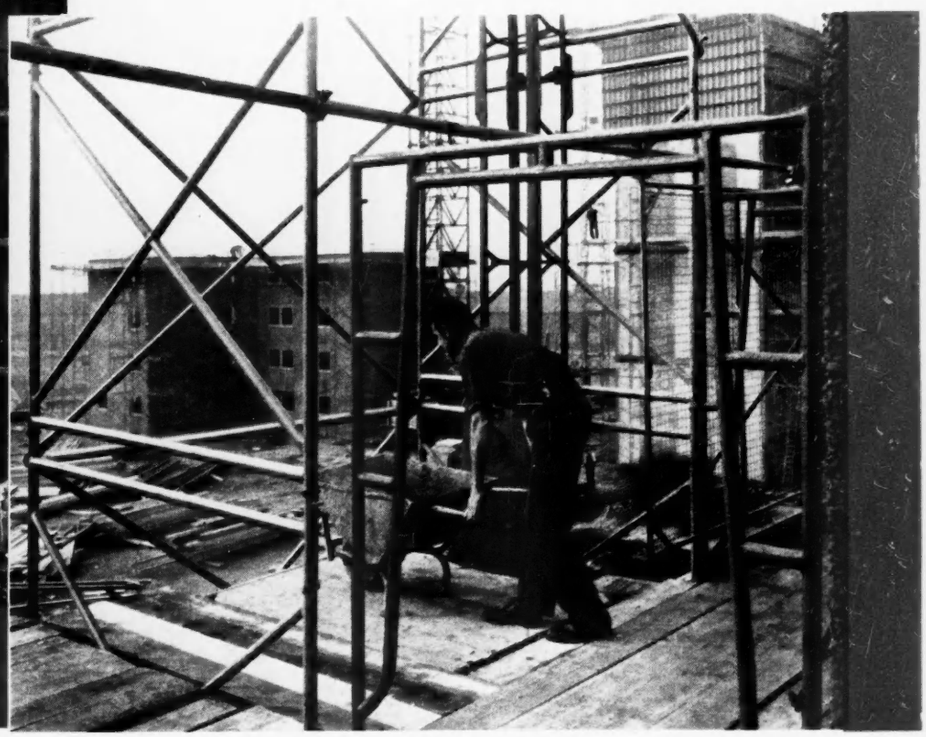

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for the substations
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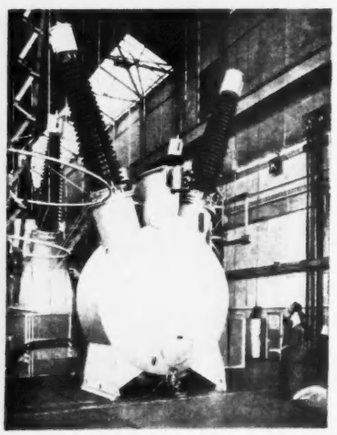

The illustrations show a complete 330 kV. bushing insulator and a 330 kV. circuit breaker, by courtesy of the B.T.H. Co.

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- No clutches, no electric motor.
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- Jibs up to 56 ft., easily erected by three men without mechanical assistance.
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- Universal foot pads.
- High torque Rotary Hydraulic Motors for precision control.
- Fully interchangeable.
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- Fast winch speeds, with Hydrocon "double safety" brakes and POWER LOWERING for precision control.
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- One rope for all jib lengths.

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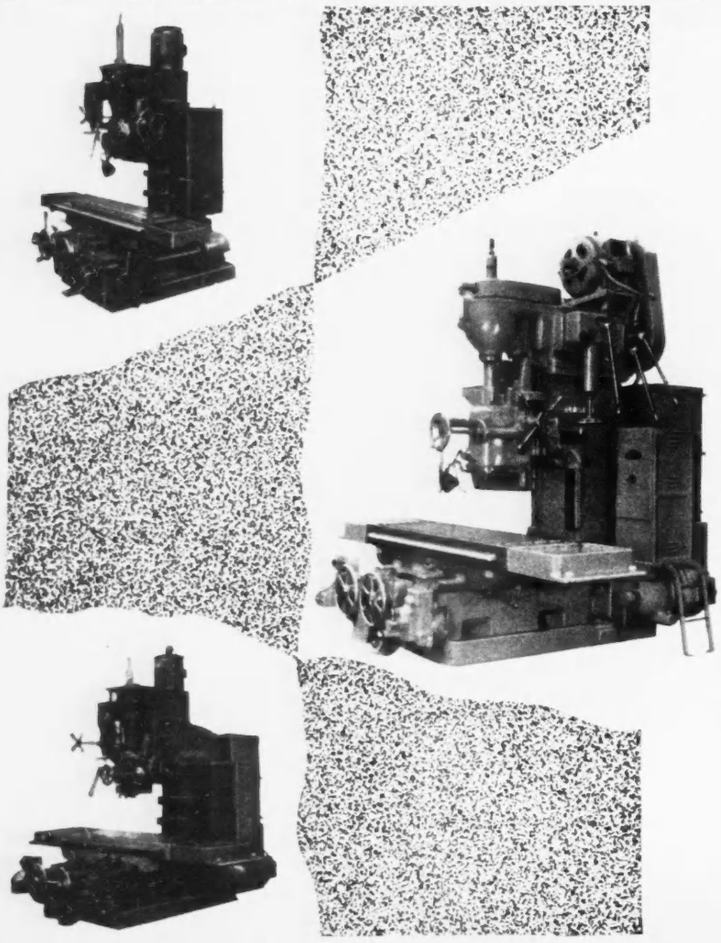

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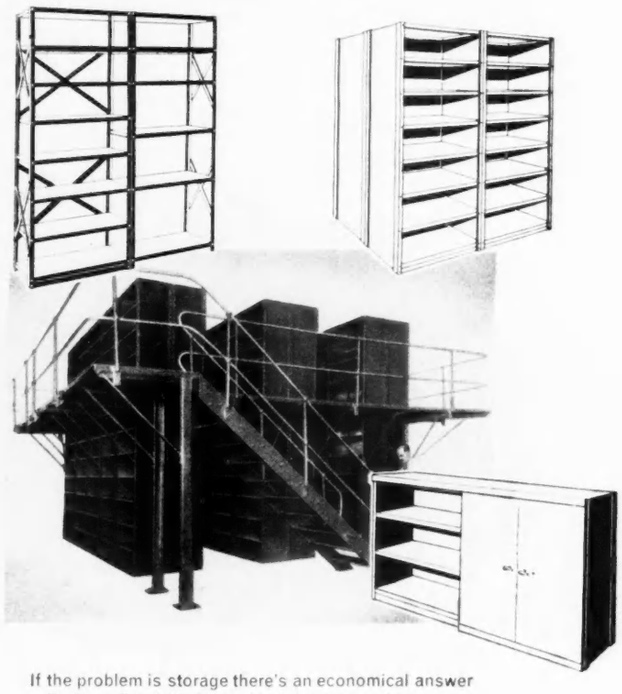

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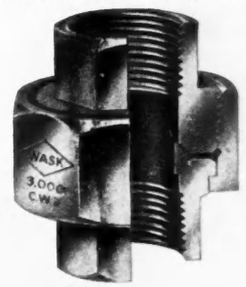

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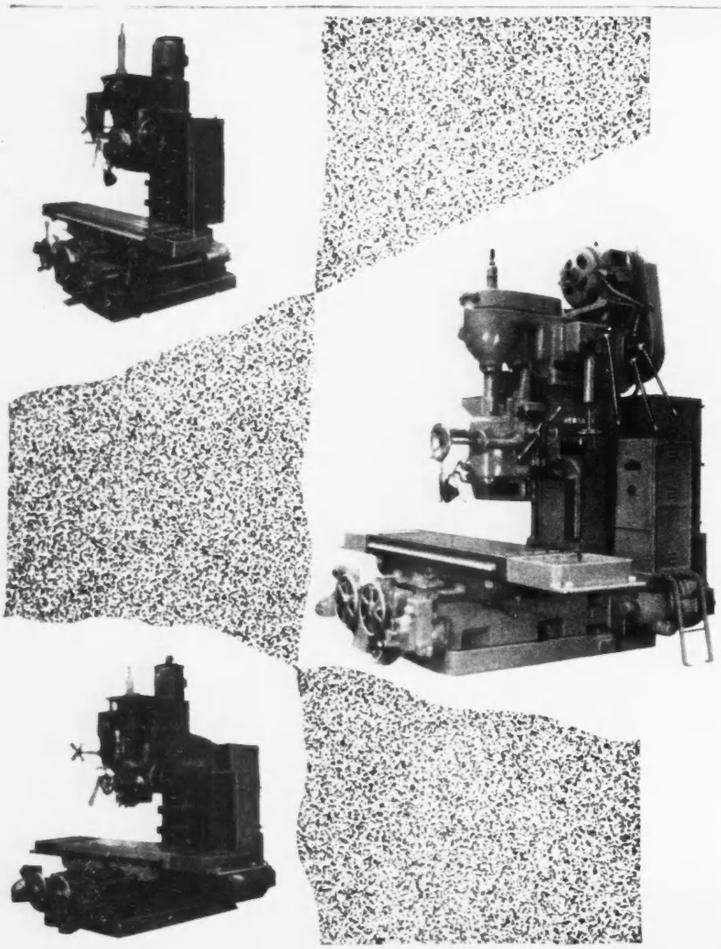

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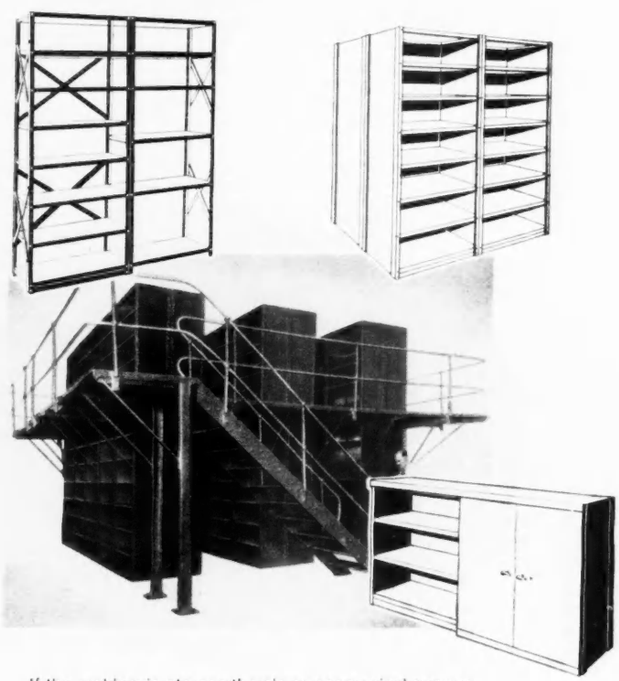

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C.W.P. non-shock
2000 lbs series
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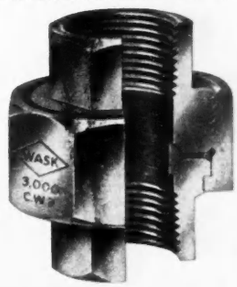

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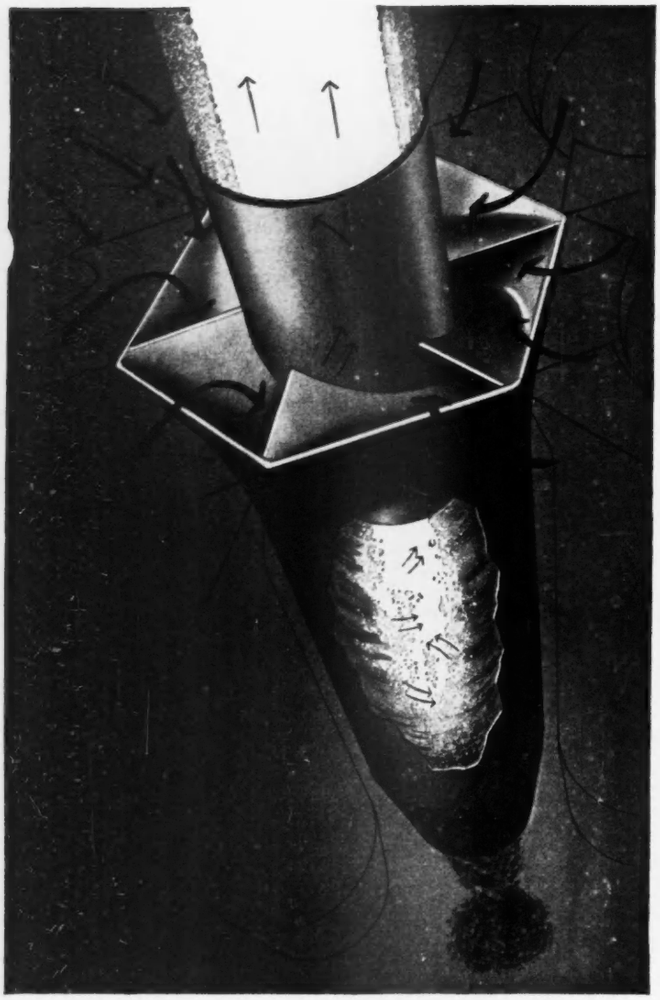

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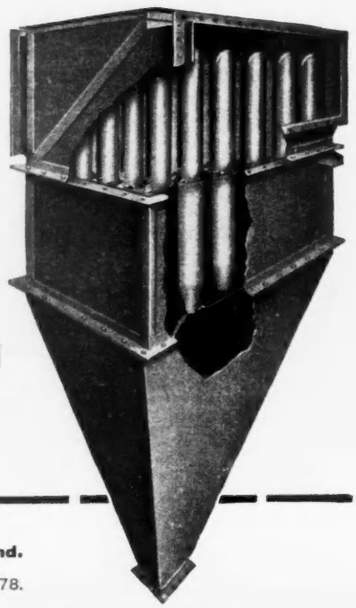

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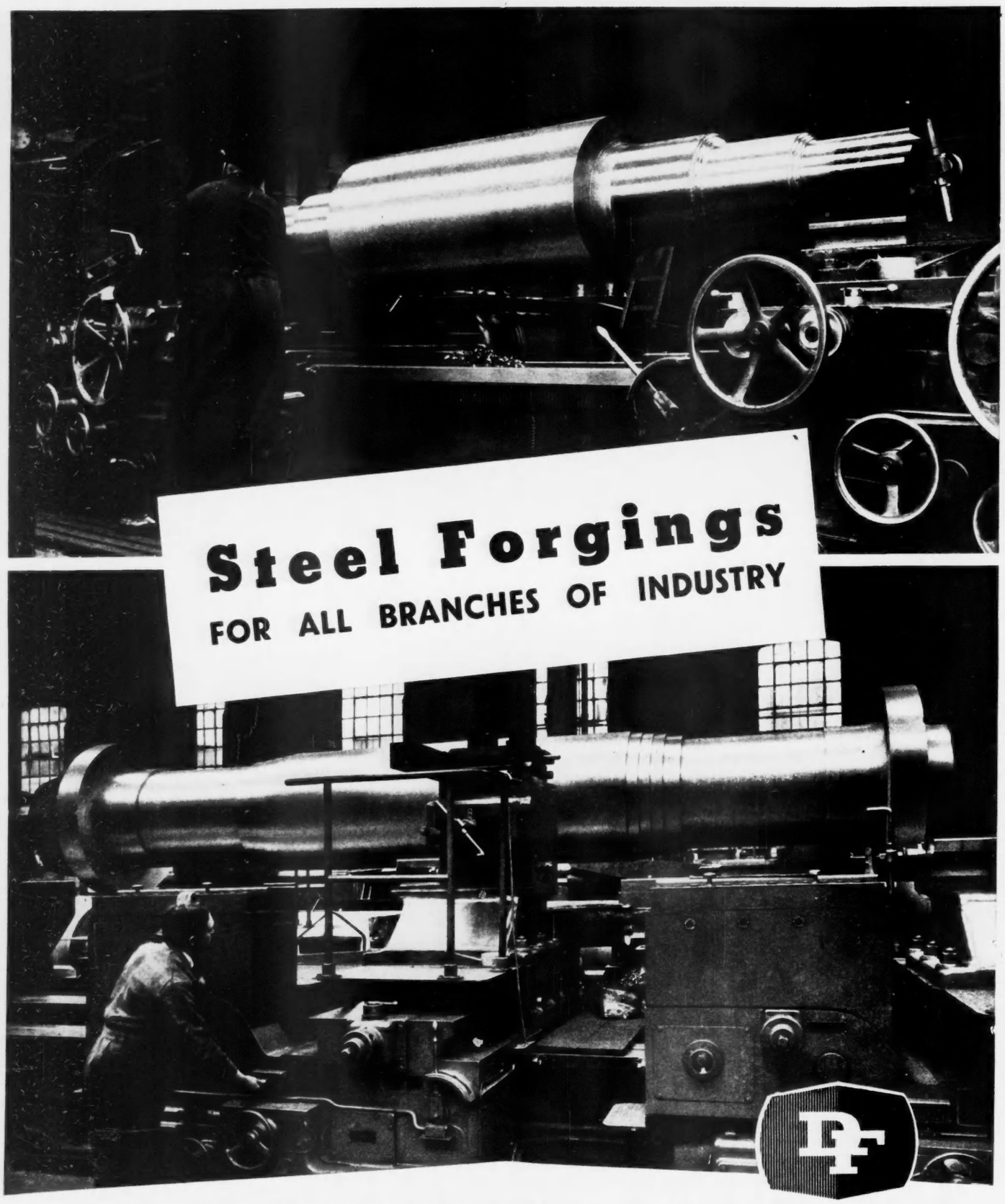

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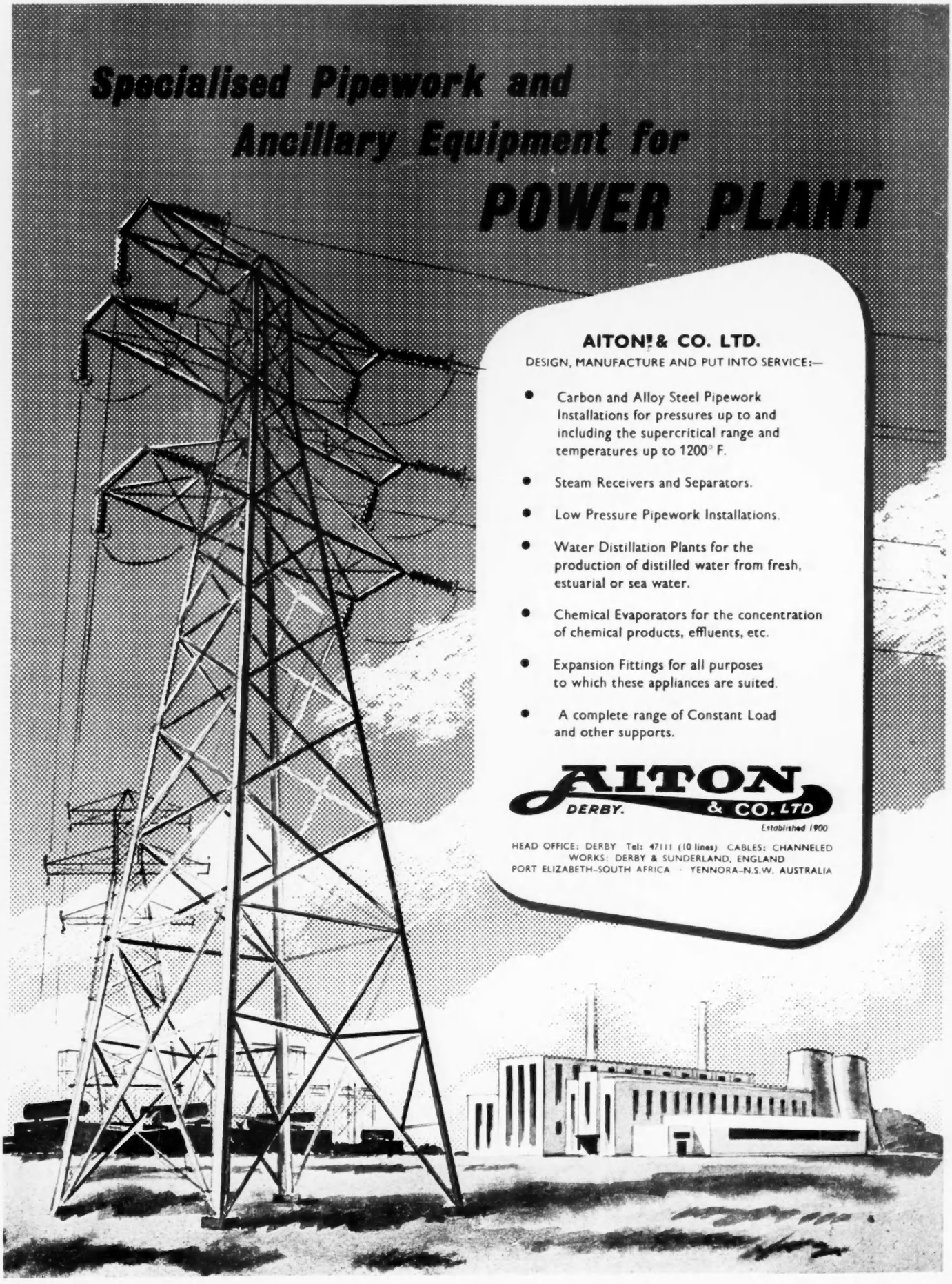

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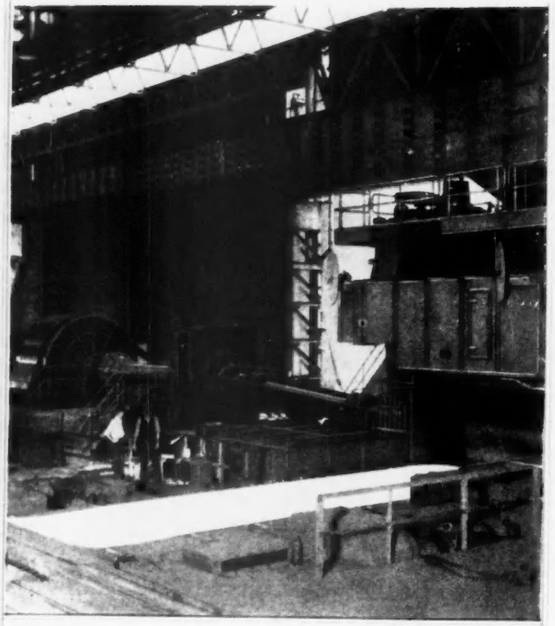

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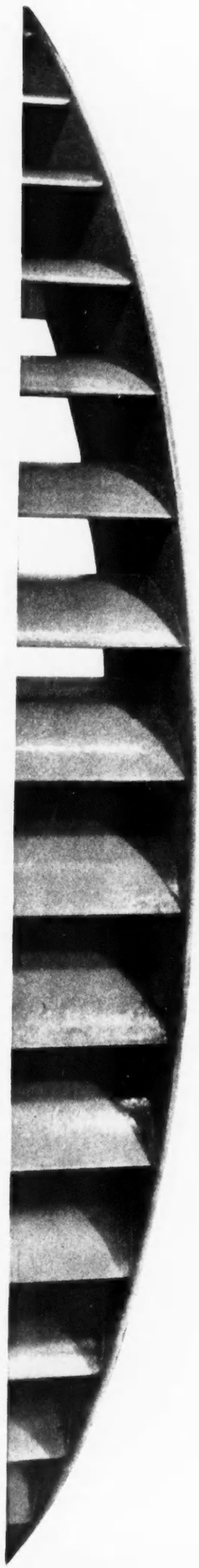
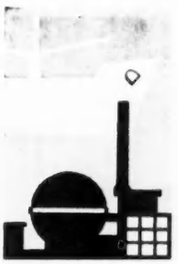


formula for leadership



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(incorporating Blackman Export Co. Ltd.)
MILL MEAD ROAD, LONDON N.17 TOTTENHAM 4522

Leaders in the Fan Industry

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Sales representatives are all fully trained technical men capable of giving 'on the spot' advice on routine applications or special problems. The sales organisation operates from branches throughout the country backed by a staff of qualified sales engineers at Head Office. Despatch of stock items, of which 5,000 units are kept continuously available, is possible in as little as four days. The Company has its own road transport fleet and direct rail connections from the main factory.

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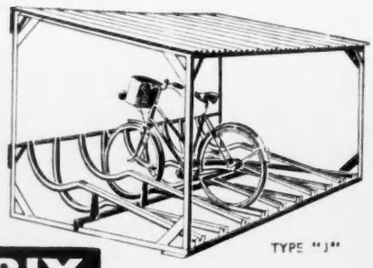

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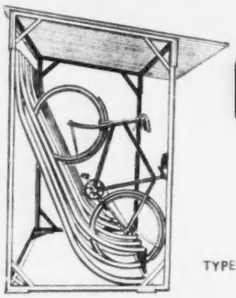

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STEEL EQUIPMENT FOR OFFICE AND FACTORY
POOL ROAD, WEST MOLESEY, SURREY

Phone: MOLesey 4361/3 Grams: Abix, East Molesey
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ANNOUNCEMENT
Laycock Engineering Limited announce that Layrub Flexible Couplings are now available for general industrial use.
As the original designers and producers of this coupling, we shall be pleased to offer full advice for its use in every form of industrial transmission however large—however small.
The Layrub Coupling needs no lubrication and it provides vibrationless, trouble-free, full transmission of power in all conditions.

LAYRUB
flexible couplings
for
INDUSTRY

LAYCOCK ENGINEERING LTD
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Victoria Works · Millhouses · SHEFFIELD 8
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RAW MATERIALS DIVISION
Established 1834

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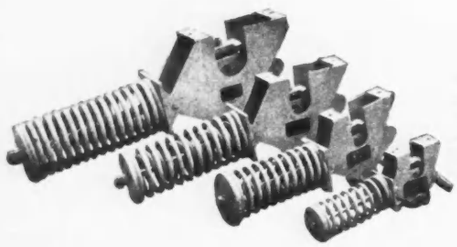
Wife, three children and 584ft of piping to support

And if he is as devoted to his job as he is to his family he will ask VokesGenspring to help him with the pipe support problem. The new 'M' range hangers are the result of long practical experience and field research. They are designed to provide a constant support for high temperature pipework over a wide range of vertical movement, thereby eliminating the dangers of increased stresses in the system and consequent joint failures and other troubles.

To ensure accurate loading over the full range including overload, every Genspring is individually checked on one of our special test rigs for which the strain gauges were calibrated by the National Physical Laboratory. *Maximum deviation can now be guaranteed at not more than 2% if required.* Test Certificates are available at time of dispatch and revised settings will be supplied if further adjustment on site is required; this adjustment can be up to 20% of rated load.

Please write for catalogue covering the 'M' range Constant Support Hangers. Load and travel characteristics are tabulated in this booklet together with much additional information including a section on determining hanger loads.



M1 to M4 Constant Supports covering loads from 315 lb. to 22,500 lb. and travels from 1.5" to 12". The latest addition to the range is Type M7 for loads up to 97,800 lb.

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VG/42

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For CASTINGS & PATTERNS OF MACHINE TOOL QUALITY CONSULT:

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MACHINING CAPACITY ALSO AVAILABLE

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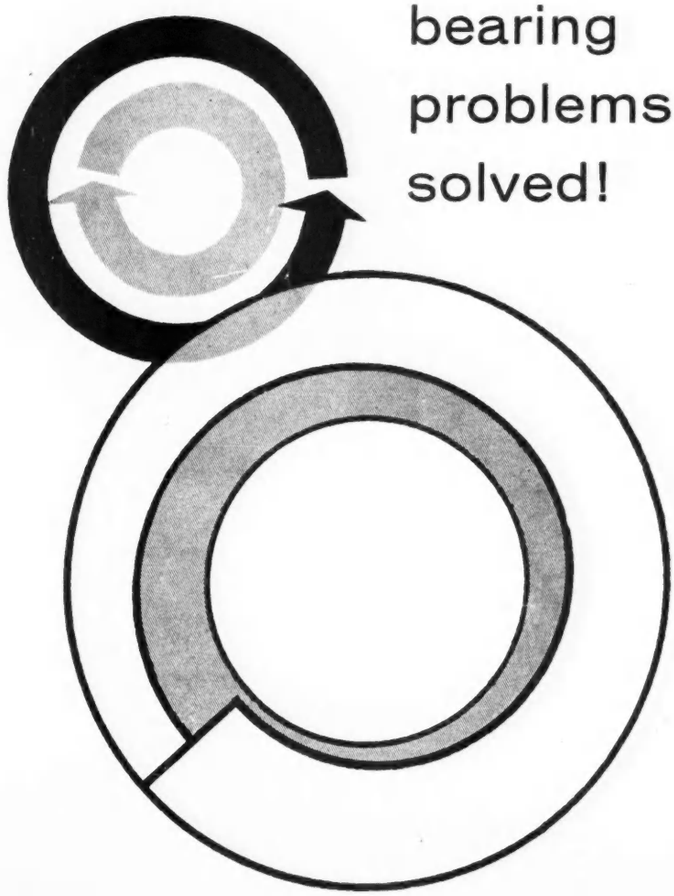
another range of bearing problems solved!



BY THE GLACIER *Anti-Whirl* BEARING

Self-exciting vibration of shafts within the oil film clearance and oil frothing are serious conditions which can halt the operation of high speed turbines and some other types of machinery.

Increased fundamental knowledge of bearings and lubrication, arising from our research programme, when applied to these problems has produced a simple new bearing design with a control valve. This enables oil film conditions in the bearing to be altered during running in such a manner as to suppress these faults.

This new bearing also provides an increased degree of damping for vibration arising from external sources.

WRITE FOR TECHNICAL DATA, ETC.,

GLACIER THE GLACIER METAL CO LTD · ALPERTON · WEMBLEY · MIDDLESEX

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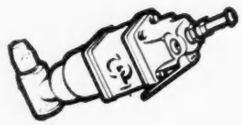
HERE ARE 7 DIFFERENT C.P. WRENCHES

One firm needs a tool for running-up nuts on $1\frac{3}{4}$" diameter bolts. Another is assembling light apparatus with $\frac{1}{4}$" bolt sizes. Yet another is faced with the problem of bolting in awkward positions and needs an angle machine. And for *all* these jobs — C.P. can supply the wrenches.

C.P. in fact make the right impact wrenches for *every* type of work — from bridge building to the manufacture of cycle components; nut running, stud setting or tapping. Seven of C.P.'s wide choice of wrenches are illustrated here; you can see the full range in the C.P. Wrench Catalogue.

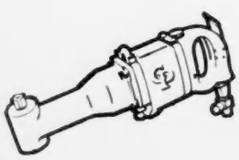
"Power Vane" 337-RS Lever Type Impact Wrench. $\frac{1}{4}$" capacity



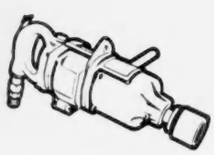
"Power Vane" 337-RAN 90° Angle Impact Wrench. $\frac{1}{4}$" capacity

"Power Vane" 344-RS Side Handle Impact Wrench. $\frac{3}{8}$" capacity

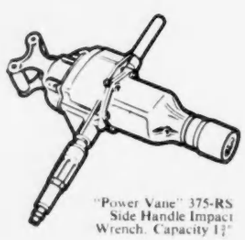
"Power Vane" 349-RP Pistol Grip Impact Wrench. $\frac{3}{8}$" capacity



"Power Vane" 349-RAN 90° Angle Impact Wrench. $\frac{3}{8}$" capacity



"Power Vane" 365-RP Pistol Grip Impact Wrench. Capacity $1\frac{1}{4}$"



"Power Vane" 375-RS Side Handle Impact Wrench. Capacity $1\frac{1}{4}$"

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CONSOLIDATED PNEUMATIC TOOL COMPANY LIMITED · DAWES ROAD · LONDON · S.W.6

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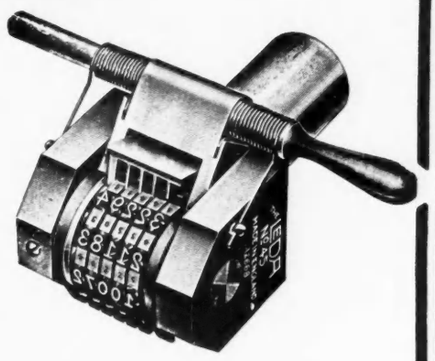
NUMBERING on METAL

"LEDA" NUMBERING MACHINES

NUMBERING HEAD for METAL



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"A complete library in two volumes . . ."

KEMPE'S ENGINEERS YEAR-BOOK

Edited under the direction of the Editor of "The Engineer"

1960 Edition price **87/6** *(plus postage 2/6)*

from technical booksellers or direct from the publishers

Kempe's Engineers Year-Book, 28 Essex Street, Strand, London, W.C.2

Telephone: CENtral 6565

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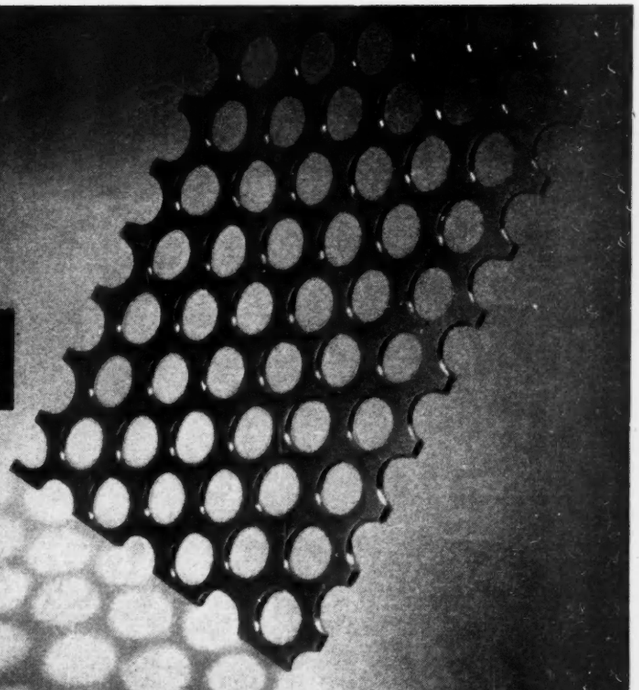
BARNS

PERFORATED METALS



W. BARNS & SON (HOLLOWAY) LTD. (Successors to W. BARNS & SON) ESTABLISHED 1860

Globe Works, Queensland Road, Holloway, N.7. Telephone: NORTH 3347/8. Telegrams: Perforation Holway, London

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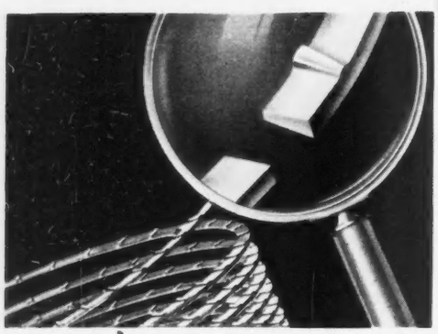
A full range of SUCTION TYPE FILTERS

Here is a full range of six standard size metal edge filters designed for immersion in a tank or casing on the suction side of any system applicable to cutting oils, hydraulic fluids, light machine oils, etc.
They are permanent, cleanable filters, efficient and reliable in action.

Six **SIZES FROM 2 g.p.m. TO 35 g.p.m.**



Purolator metal edge filters consist of a patented edge-wound metal ribbon of tapering cross-section that presents a rigid surface to the incoming fluid. The precision formed ribbon is closely wound under tension on to a supporting frame and securely fixed at each end. Projections on the ribbon, which are of uniform height and formed at defined intervals along its surface, give a degree of filtration from ·002" to ·020" as required. These filters can be supplied in brass, monel metal or stainless steel materials.

PUROLATOR
REGD. TRADE MARK
METAL-EDGE FILTERS

AUTOMOTIVE PRODUCTS COMPANY LTD
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND
ONE OF THE AUTOMOTIVE PRODUCTS GROUP

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GERMAN INDUSTRIES FAIR
HANNOVER
24 APRIL — 9 MAY 1960

FOR FURTHER PARTICULARS PLEASE APPLY TO
DEUTSCHE MESSE- UND AUSSTELLUNGS-AG.
HANNOVER MESSEGELANDE

UNION DES FOIRES INTERNATIONALES

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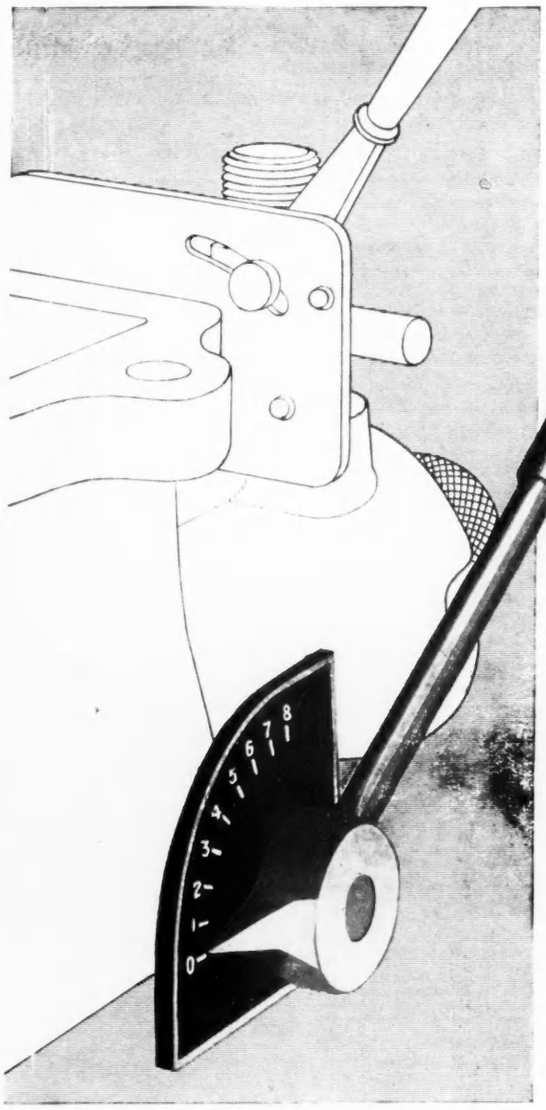
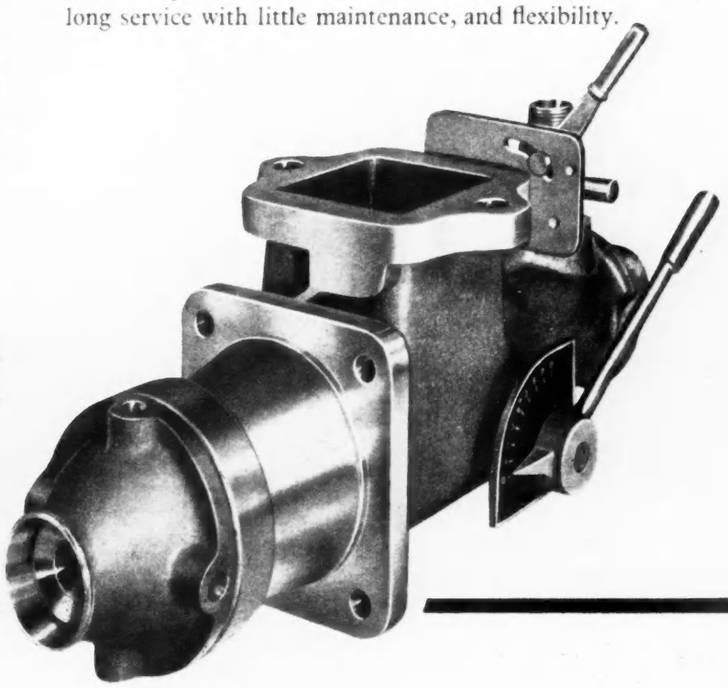


The Burner shown has a maximum output of 12 gallons per hour and requires atomising air at 20" (51 cm) w.g. to 30" (76 cm) w.g. with oil at not less than 5 lbs per sq. in. (0.35 kgs. per sq. cm.) or equivalent head.

Made to Measure

WALLSEND SELF-PROPORTIONING LOW AIR PRESSURE BURNER

- . . specially designed so that the fuel output and air/oil ratios are under complete control.
- . . provides fingertip, single lever control for accurate and efficient regulation.
- . . automatically ensures a correct mixture of air and oil over a wide range irrespective of the type of fuel in use.
- . . has a turn down range of approximately 5 : 1 which can be achieved with a stable flame, efficient combustion and a high CO_2 content.
- . . leads the way to automatic or remote control of single and multi-burner installations.
- . . incorporates the well known Wallsend features of robustness, long service with little maintenance, and flexibility.



For more efficient **OIL BURNING** consult

THE WALLSEND SLIPWAY & ENGINEERING COMPANY LIMITED

WALLSEND-ON-TYNE

NEARLY 80 YEARS OF OIL BURNING EXPERIENCE

In association with HUBBARD COMBUSTION LIMITED, Kingston on Thames.

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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an Illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

***Advertisements for publication should be addressed to :*—Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

GOVERNMENT OF WESTERN NIGERIA

VACANCY FOR CHIEF TECHNICAL EDUCATION OFFICER

Applications are invited for the post of CHIEF TECHNICAL EDUCATION OFFICER.

Qualifications. Candidates must possess a degree of a recognised University in Engineering or Pure Science. Applicants should have had wide teaching and Administrative experience in Technical Education up to and including at least the status of a Head of Department in a Technical College in the United Kingdom and be prepared to accept responsibility for the general development of Technical Education in the Region.

Duties. To advise the Permanent Secretary, Ministry of Education on the progress and development of Technical Education in the Western Region of Nigeria. The Officer appointed will have primary responsibility in developing and correlating the facilities to be provided for Technical Education in the Region and will be concerned with the operation and functioning of Trade Training Centre, Handicraft Centres, Secondary Technical Schools, Technical Institutes and Technical Colleges.

Terms of Appointment. On contract terms for a minimum of two tours of 12-18 months each in the first instance on a consolidated salary of £2244 per annum, plus gratuity at the rate of £37 10s. for each completed three months' service. Free first class passages for officer and his family on first appointment and when proceeding on leave ; free medical treatment for officer and his family. Accommodation is provided at low rentals.

Applications should be completed in triplicate on the prescribed form obtainable from the Official Secretary (Recruitment Branch), Office of the Commissioner for Western Nigeria, 178-202, Great Portland Street, London, W.1, from whom further particulars may also be obtained.

Closing date : 2nd April. E9276

UNIVERSITY OF KHARTOUM

LECTURESHIPS

Applications are invited for a SENIOR LECTURESHIP or LECTURESHIP in the Department of Engineering Mathematics ; LECTURESHIP in Electrical Engineering ; SENIOR LECTURESHIP or LECTURESHIP in Mechanical Engineering.

Salary Scales : Senior Lecturer : £S.2052 by £S.75 to £S.2127 p.a.

Lecturer : £S.1077 by £S.75 to £S.1977 p.a.

Entry point according to qualifications and experience. Cost of living allowance approximately £S.180 p.a. Outfit allowance £S.50. Family allowances : Wife £S.60 p.a., 1st child £S.90 p.a., 2nd and 3rd child £S.30 p.a. each. (£S.1=£1. 0s. 6d. sterling.) Passages for appointee and family on appointment, termination and annual leave. Initial appointment 5 years, with possible renewal. Superannuation scheme ; arrangements can be made to maintain F.S.S.U. policies. Unfurnished accommodation provided at rent up to 7½ per cent of salary.

Applications (10 copies) detailing qualifications and experience and naming 3 referees by 20th April, 1960, to Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E9294

WEST RIDING COUNTY COUNCIL

CASTLEFORD : WHITWOOD MINING AND TECHNICAL COLLEGE

ASSISTANT GRADE "A"

ASSISTANT, Grade "A," required, to teach Engineering subjects in Preliminary S.1 and S.2 stages of craft courses, with an opportunity to specialise in the teacher's chosen craft. Salary scale : £520 by £27 10s. to £1000, with allowances for approved qualifications, war service, training and industrial experience.

Application forms and further particulars obtainable from J. W. Davies, 2, Wesley Street, Castleford. E9305

PUBLIC APPOINTMENTS

UNIVERSITY OF KHARTOUM

TUTORIAL DRAUGHTSMAN IN THE DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for the position of TUTORIAL DRAUGHTSMAN in the Department of Mechanical Engineering.

Salary Scale : Either Senior Technician : £S.1250 by £S.50 to £S.1500 p.a.

Technician : £S.950 by £S.50 to £S.1200 p.a.

Entry point according to qualifications and experience. Cost of living allowance now approximately £S.180 p.a. Outfit allowance £S.50. Family allowance : Wife £S.60 p.a., 1st child £S.90 p.a., 2nd and 3rd child £S.30 p.a. each. (£S.1=£1. 0s. 6d. sterling). Passages for appointee and family on appointment, termination and annual leave. There is a superannuation scheme, and arrangements can be made to maintain F.S.S.U. policies. Appointment on contract for 3 years with possibility of renewal. Unfurnished accommodation provided at rent up to 7½ per cent of salary.

Applications (10 copies) detailing qualifications and experience and naming 3 referees by 20th April, 1960, to Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E9292

MIDDLESEX COUNTY COUNCIL
EDUCATION COMMITTEE

HENDON TECHNICAL COLLEGE, THE BURROUGHS, HENDON, N.W.4

LECTURERS

Applications are invited for the following posts, most of which are new posts due to the expansion of the College's advanced work. Successful applicants will be expected to take up their duties in September, 1960.

MECHANICAL ENGINEERING DEPARTMENT

(1) PRINCIPAL LECTURER, to teach Applied Thermodynamics to post-Higher National Diploma level. Candidates must possess high academic qualifications and be Corporate Members of the Institution of Mechanical Engineers. Appropriate teaching and industrial experience essential.

(2) SENIOR LECTURER, to teach Strength of Materials to Higher National Diploma level.

(3) LECTURER, to teach Theory of Machines to Higher National Certificate level.

(4) LECTURER, to teach Metallurgy to Higher National Certificate level.

Candidates for posts (2), (3) and (4) should be Graduates and must have both industrial and teaching experience.

Salary within the range :
Principal Lecturers : £1788–£1951 per annum.
Senior Lecturers : £1588–£1801 per annum.
Lecturers : £1408–£1601 per annum.

Application forms (S.A.E.) and further details of all posts may be obtained from the Clerk to the Governing Body, Town Hall, The Burroughs, Hendon, N.W.4, to whom completed applications should be returned within two weeks of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
E9300 Secretary to the Education Committee.

UNIVERSITY OF KHARTOUM

CHAIR OF MECHANICAL ENGINEERING

Applications are invited for the Chair of Mechanical Engineering.

Salary : £S.2760 per annum.

Cost of living allowance approximately £S.180 p.a. Outfit allowance £S.50. Family allowance : Wife £S.60 p.a., 1st child £S.90 p.a., 2nd and 3rd child £S.30 p.a. each. (£S.1=£1. 0s. 6d. sterling.) Passages for appointee and family on appointment, termination and annual leave. Superannuation scheme ; arrangements can be made to maintain F.S.S.U. policies. Appointment on contract for 5 years with possibility of renewal. Unfurnished accommodation provided at the rate of 7½ per cent of salary.

Applications (10 copies) detailing qualifications and experience and naming 3 referees by 20th April, 1960, to Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained. E9293

PUBLIC APPOINTMENTS

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

APPOINTMENT OF LECTURER OR ASSISTANT LECTURER IN MECHANICAL ENGINEERING

The Governing Body invites applications for a LECTURESHIP or ASSISTANT LECTURESHIP IN MECHANICAL ENGINEERING in the Manchester College of Science and Technology, with corresponding title and status in the University of Manchester.

The Department covers a very wide field in Mechanical Engineering, including Photoelasticity, Fatigue, Servo-mechanisms, Vibrations, Machine Tools and Production Processes and Heat Transfer. A special high level Diploma Course in Machine Tool Design, lasting two years, has just been inaugurated. All members of staff are expected to undertake, assist in or supervise research, for which facilities are excellent. The Teaching is almost entirely confined to Graduate and Post Graduate Courses for Internal Degrees and Diplomas. Short courses for specialists in subjects of particular interest are offered each year. Salary, according to qualifications and experience, in the scale £900 by £50 to £1350 by £75 to £1650 (Lecturer), or £700 by £50 to £850 (Assistant Lecturer). F.S.S.U. and family allowances.

Conditions of appointment and form of application may be obtained from the Registrar, The Manchester College of Science and Technology, Sackville Street, Manchester, 1. The last day for the receipt of applications is Saturday, 16th April, 1960. E9255

MIDDLESEX COUNTY COUNCIL
EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE, QUEENSWAY, ENFIELD, MIDDLESEX

SENIOR LECTURER AND LECTURER

Required :

(1) SENIOR LECTURER IN CIVIL ENGINEERING, to teach Theory of Structures and Surveying to Final Diploma standard. Candidates must be University Graduates in Civil Engineering, Corporate Members of the Institution of Civil Engineers, and have had industrial, teaching and/or research experience.

(2) LECTURER IN CIVIL ENGINEERING, to teach Civil Engineering subjects up to Diploma standard. Candidates must be University Graduates in Civil Engineering and at least Graduate Members of the Institution of Civil Engineers. They should have had industrial and/or teaching experience.

Salary within the range :
Senior Lecturers : £1588–£1801 per annum.
Lecturers : £1408–£1601 per annum.

Application forms (foolscap S.A.E.) from the Principal, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
E9301 Secretary to the Education Committee.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

HYDRAULICS RESEARCH STATION, WALLINGFORD, BERKS

ENGINEER OR PHYSICIST

D.S.I.R., Hydraulics Research Station, Wallingford, Berks, requires ENGINEER OR PHYSICIST (Graded as Scientific Officer/Senior Scientific Officer) with interest in fluid mechanics, for work in field of Civil Engineering Hydraulics. Opportunities of undertaking both background and fundamental research and investigation of specific problems. Favourable housing prospects for married officer. Qualifications : 1st or 2nd Class Honours degree in Physics or Engineering or equivalent. At least 3 years' post-graduate experience required for S.S.O. Salary ranges : (Men) S.O. £615 to £1090 ; S.S.O. £1166 to £1380. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.129/OA. E9317

PUBLIC APPOINTMENTS

BOROUGH POLYTECHNIC,
BOROUGH ROAD, S.E.1.

Principal : JAMES E. GARSIDE, M.Sc. Tech., Ph.D., F.R.I.C., F.I.M., F.Inst.F.

LECTURERS

The Governors invite applications for the following appointments :

Department of Electrical Engineering and Physics

Head of Department : V. Pereira-Mendoza, M.Sc. Tech., M.I.E.E.

LECTURER IN ELECTRICAL ENGINEERING

Applicants should be University Graduates in Electrical Engineering and have had responsible industrial, research and/or teaching experience. Specialised knowledge and experience in Electrical Power Engineering is required for lecturing to Dip.Tech. and Part III I.E.E. courses and for developing research projects in this field. Excellent research facilities.

Department of Mechanical Engineering

Head of Department : G. L. H. Bird, B.Sc. (Eng.), M.I.Mech.E., M.Inst.R.

TWO LECTURERS IN MECHANICAL ENGINEERING

Applicants should be University Graduates in Mechanical Engineering and have had responsible industrial, research and/or teaching experience. Duties will involve advanced "Sandwich" courses. Excellent opportunities and facilities for research.

For one post the Lecturer will be mainly concerned with Engineering Production subjects. A Post-Graduate or professional qualification in Production Engineering would be an added qualification, together with specialised knowledge and experience in some aspect of this subject.

For the other post, the Lecturer will be mainly engaged upon Engineering Thermodynamics and Heat Transfer Theory, and appropriate knowledge and experience is expected.

Salary (Men) : Lecturers, within the range £1408 to £1601 per annum. The point of entry on the salary scale and the maximum depending on age, qualifications, training and experience.

Further particulars and Application Form, which should be returned as soon as possible, obtainable from the undersigned.

FREDK. J. PACKER,
E9259 Clerk to the Governing Body.

MINISTRY OF AVIATION

LONDON AND MOTTINGHAM

TECHNICIANS

Ministry of Aviation requires TECHNICIANS in London and Mottingham to prepare estimates of prime cost of manufacture of engineering productions. Qualifications : Recognised engineering apprenticeship or equivalent training in an appropriate trade. Good practical experience in ratefixing, operational planning and prime cost estimating. There are vacancies in Sections concerned with general mechanical and electrical productions, manufacture of electronic equipments, and work requiring very good machine shop experience. O.N.C., C. and G. Finals or equivalent. Salary ; £900 (age 30) to £1065 p.a. Application forms from Manager (P.E.1055), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E9316

KINGSTON GROUP HOSPITAL MANAGEMENT COMMITTEE

ASSISTANT ENGINEER

Applications are invited for the appointment of ASSISTANT ENGINEER for general duties in the Group, from candidates who have completed an apprenticeship in mechanical engineering and have experience, preferably in a hospital, of the principles and practice of the efficient operation of steam and oil-fired boiler plants. Ordinary National Certificate in Mechanical Engineering desirable. Pension scheme in force. Salary scale £575 by £25 (5) to £700 per annum plus London Weighting (commencing point according to previous experience). Apply with details of age, qualifications and previous experience, with names of two referees, to Group Secretary, Kingston Group Hospital Management Committee, 35, Coombe Road, Kingston upon Thames, Surrey. E9322

PUBLIC APPOINTMENTS

REPUBLIC OF THE SUDAN

SUDAN RAILWAYS

SENIOR MECHANICAL ENGINEER

Applications are invited from those suitably qualified to fill a vacancy as SENIOR MECHANICAL ENGINEER in the Sudan Railways.

Candidates must be fully qualified Mechanical Engineers in theory and practice, have graduated in Mechanical Engineering and/or must be a Corporate Member of the Institution of Mechanical Engineers, and have served a full apprenticeship on railways or with a firm of locomotive builders of repute, and have held a position of responsibility on locomotive engineering of not less than 15 years. Should be familiar with steam and diesel electric locomotives from both maintenance and running points of view.

Should have experience on progress work, full control and piece work. Appointments will be on contract, with bonus, for a period of three years determinable at any time by three months notice on either side. Bonus of one month's salary will be paid for each year of satisfactory service.

Salary range £S.1750 to £S.2170 with annual increments. Starting rate will be fixed according to age, experience and qualifications. £S.1 equals £1 0s. 6d. sterling.

Age limit 40–55 years.

A cost of living allowance is payable—the present rate being £S.187 per annum. An outfit grant of £S.50 is payable on appointment.

Annual leave after the first tour.

At the present time there is no income tax in the Sudan.

Write for further particulars and application forms to: Appointments Section, The Sudan Embassy, Cleveland Row, St. James's, London, S.W.1, quoting reference L.E.7-4/1936. Closing date, 30th April, 1960. E9257

CITY OF BRADFORD SEWAGE DEPARTMENT

ASSISTANT ENGINEER

Applications are invited for the above superannuable appointment in Special Grade (£785–£1070) in the office of the Sewage Works Engineer and Manager, Esholt Hall, near Shipley, Yorkshire. Commencing salary according to qualifications and experience.

Candidates should have received a good training in civil engineering. Minimum qualifications required are Graduate Membership of the Institution of Civil Engineers, or Final Examination of the Institution of Municipal Engineers. Experience in the design of sewerage and sewage disposal works would be an advantage.

Applications, stating age, experience and qualifications together with the names of two referees, and enclosed in an envelope endorsed "Assistant Engineer, Sewage Department," should reach me by 4th April, 1960.

HENRY PATTEN,
Town Clerk.
Town Hall,
Bradford, 1. E9201

CENTRAL ELECTRICITY GENERATING BOARD

EASTERN DIVISION

SENIOR DRAUGHTSMAN

Applications are invited for the following appointment at Divisional Headquarters (Cockfosters).

SENIOR DRAUGHTSMAN

Salary: N.J.B., Schedule D, Grade 5, £830 by £20 to £940, inclusive of London Weighting.

The duties of the successful applicant will include work on the layouts for high voltage transmission lines and substations.

Applicants should have technical qualifications to the standard of Ordinary National Certificate and should have had experience of this type of work.

Applications, quoting Staff Vacancy Number 1287, stating age, qualifications, experience and present position, should be sent to the Controller, Central Electricity Generating Board, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts., to arrive not later than 2nd April, 1960. E9268

PUBLIC APPOINTMENTS

BASILDON DEVELOPMENT CORPORATION

CHIEF ENGINEER'S DEPARTMENT

APPOINTMENT OF SENIOR ENGINEER —GRADE A.P.T. IX

Applications are invited for the above post within the salary range £1527 and £1755. The post is subject to the provisions of the Local Government Superannuation Acts, 1937–53, and to three months' notice on either side.

Candidates should be corporate members of the Institution of Civil Engineers and should have had at least seven years' first class experience in a Municipal or Consulting Engineers' Office or similar employment.

The successful candidate will be required to take charge of one of the four sections into which the Chief Engineer's Department is divided.

The programme for construction of engineering work at Basildon is at its peak and many interesting projects are programmed for design and construction during the next five years. These include main roads, bridges, flyover and roundabout type junctions, trunk sewers and development of Town Centre, Industrial and Housing Areas.

Applications stating age, education, training and experience and accompanied by the names and addresses of three persons to whom reference as to character and professional skill may be made must be received not later than Monday, 4th April, 1960, by the General Manager, Gifford House, Basildon, Essex. Please quote Ref. No. GM.7131. E9280

MINISTRY OF AVIATION

ENGINEERS AND CHEMISTS METALLURGISTS AS TECHNICAL ASSISTANTS

Ministry of Aviation requires ENGINEERS and CHEMISTS/METALLURGISTS as TECHNICAL ASSISTANTS in Inspectorates, to undertake training for executive responsibility, and practical use of tools of management. Vacancies in various parts of Great Britain.

Duties: (a) inspection of armament stores, including development of new techniques and skills and metrology of components made to fine limits, or (b) technical direction of inspection of tracked and wheeled vehicles and Royal Engineer equipment and stores.

Qualifications: Preferably not more than 32 years of age and British of British parents. Engineers—engineering apprenticeship and exemption from the Graduate Membership examinations of the Institutions of Civil, Mechanical or Electrical Engineers. Chemists—suitable training and exemption from Graduate Membership examinations of the Royal Institute of Chemistry, Institution of Metallurgists, Institute of Physics, or Institution of Chemical Engineers. Candidates required to produce documentary evidence of qualifications on interview. Prospects: Opportunities for promotion and establishment in professional Classes for appropriately qualified candidates through Civil Service Competitions.

Salary: £595 £950 per annum, according to age and location.

Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C.260/OA, and stating preference (a) or (b) above and location. Closing date: April 14, 1960. E9306

CITY OF COVENTRY WATER UNDERTAKING

ENGINEERING ASSISTANT

Applications are invited from suitably qualified engineers for a post in the Supply Works Group requiring mechanical and electrical engineering experience. Salary according to qualifications and experience within A.P.T. IV (£1065 to £1220)/Special (£785 to £1070).

Housing accommodation may be provided and a removal expenses loan may be considered.

Closing date, 1st April, 1960.

Further particulars and conditions from Water Engineer and Manager, Waveley Road, Coventry. E9258

PUBLIC APPOINTMENTS

RHODESIA RAILWAYS

VACANCIES FOR SIGNALS AND COMMUNICATIONS ENGINEERS

Vacancies exist on the Permanent Staff for Signals and Communications Engineers for service in the Chief Engineer's Department of the Rhodesia Railways.

Preference will be given to applicants who have had previous experience in the design, installation and maintenance of modern colour light signalling and/or telecommunication systems with a Railway Administration or with a firm of equipment manufacturers.

Applicants should hold a degree in Electrical Engineering at a recognised University or be Corporate Members of the Institution of Electrical Engineers. Applicants who have passed Parts I and II of the Institution examinations will be considered for appointment to the grade of Technical Assistant until such time as they become Corporate Members and are, therefore, eligible for transfer to the Professional Grade. Successful candidates will be expected to become Corporate Members of the Institution of Railway Signal Engineers in due course.

The salary scale for Assistant Engineers is £1000 to £1800 per annum, plus a Cost of Living Allowance at present calculated on 12 per cent of the basic salary, subject to a maximum of £13 15s. per month. The commencing salary will depend upon previous experience of applicants. The annual increments in the above scale are as follows:

£1000 by £100 to £1200.
£1200 by £50 to £1500.
£1500 by £100 to £1800.

Further advancement to the grade of District Signals and Communications Engineer on the salary scale £1800 by £100 to £2100 is possible as and when vacancies occur. Promotion to these posts is by selection.

Membership of the Contributory Pension Fund and Medical Fund is obligatory, and the usual Railway privileges in respect of travelling concessions, leave, &c., will apply.

Income Tax in the Federation is not unreasonable, and at the present time, a married man with one child, earning £1100 per annum would not be liable.

Housing is provided at a moderate rental for married Engineers; the rental payable is £7 10s. per month for Officers in receipt of a salary under £1700 per annum, and £10 per month for Officers in receipt of higher salaries.

Full particulars with regard to age, training, qualifications and experience should be submitted together with copies of recent testimonials to:

The London Agent,
Rhodesia Railways,
241, Salisbury House,
London Wall,
London, E.C.2,

from whom full details regarding conditions of service may be obtained. E9204

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS, for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1095 at 34 or over thereafter rising to maximum £1260, with increase for London and slight decrease for country districts. Appointments non-pensionable but long-term. Promotion prospects 5-day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service.

Qualifications and experience:

( ) (a) University Degree or equivalent Diploma in Electrical and/or Mechanical Engineering with at least 2 years' apprenticeship; or
(b) Graduate or Corporate Member of I.E.E., with at least 3 years' apprenticeship; or
(c) Graduate or Corporate Member of I Mech.E., appreciable electrical engineering experience, with at least 3 years' apprenticeship; and

(ii) Have been employed for minimum of 2 years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects, between ages of 25 and 45.

Forms from Ministry of Labour, Technical and Scientific Register (K) 26, King Street, London, S.W.1, quoting D.158/OA. E9142

CHESHIRE RIVER BOARD

BIRKET AND FENDER IMPROVEMENT SCHEME—MORPETH BRANCH DOCK

RESIDENT ENGINEER

Applications are invited for the temporary appointment of RESIDENT ENGINEER, to supervise the construction of a Pumping Station in a reclaimed portion of the Morpeth Branch Dock, Birkenhead, diversionary works to the Great Culvert, a discharge culvert constructed in tunnel in the dock wall and the erection of pumping plant.

Salary: £1800 per annum for the duration of the appointment, which is expected to be 3 years, commencing mid-1960.

Conditions of service as Parts 2, 4 and 5 only of the Scheme of Conditions of Service issued by the National Joint Council for Local Authorities, Administrative, Professional, Technical and Clerical Staffs.

Applications, endorsed "Resident Engineer," giving full particulars of age, qualifications, experience and also the names of two persons to whom reference can be made, should reach the undersigned not later than 4th April, 1960.

SANDFORD FAWCETT AND PARTNERS,
Consulting Civil Engineers.
53, Victoria Street,
Westminster,
London, S.W.1.
15th March, 1960. E9264

PUBLIC APPOINTMENTS

CITY OF HOBART, TASMANIA—AUSTRALIA

ENGINEERS

Due to an accelerated programme of Works to match an expanding City, the Hobart City Council requires additional Engineering staff, and the following vacancies exist:

CITY ENGINEER'S DEPARTMENT

1. ASSISTANT DESIGN ENGINEER. Present salary £A1752 £A1798 £A1846.*

Duties: To direct and control the activities of the Design Office under the Design Engineer.

Qualifications: (a) Corporate Membership of the Institution or equivalent. (b) Experience in design and construction and in handling staff. Managerial ability is stressed.

2. ASSISTANT PLANNING ENGINEER. Present salary £A1752 £A1798 £A1846.*

Duties: (a) Pre-planning and programming projects and co-ordinating field works. (b) Budget and cost control.

Qualifications: (a) Corporate Membership of the Institution or equivalent. (b) Construction experience in civil or municipal works. (c) Costing and estimating experience is desirable.

3. HYDRAULIC ENGINEER (INVESTIGATION). Present salary £A1752 £A1798 £A1846.*

Duties: Responsible for investigations and design of works relating to the supply of water to the City.

Qualifications: (a) Corporate Membership of the Institution or equivalent. (b) Experience in Civil Engineering designs, especially hydraulic structures and works.

* (Marginal increase under consideration.)

Conditions of appointments:

(a) Three weeks' annual leave, long service leave after 10 years' service, liberal sick leave and superannuation benefits are available.

(b) Assistance will be given in finding adequate accommodation and in moving expenses (if applicable).

(c) Applications, giving full particulars of age, experience and present position, together with testimonials, to be sent to the undersigned, close at noon on 11th April, 1960.

H. J. R. COLE,
Town Clerk.
E9209

TENDERS

TEES VALLEY AND CLEVELAND WATER BOARD

LARTINGTON RAPID GRAVITY FILTRATION PLANT

In connection with the CONSTRUCTION of a RAPID GRAVITY FILTRATION PLANT at Lartington, near Barnard Castle, Co. Durham, the Board invites TENDERS for the work scheduled below:

Contract No. 97.—The Provision, Erection and Setting to Work of an Oil-Fired Central Heating Plant of approximately 2,000,000 B.Th.U./hour capacity, together with Ancillary Equipment.

Contract No. 100—The Provision, Erection and Setting to Work of an Automatically Operated Standby Diesel Engine Driven Alternator of approximately 310kVA capacity.

Only Contractors thoroughly experienced in the design and execution of the work described above should apply; they will be required to furnish details of installations of a similar character which they have previously carried out.

Contractors who wish to Tender for either of the above Contracts should make application in writing not later than 10 a.m. on Tuesday, 5th April, 1960, to T. S. R. Winter, Esq., M.I.C.E., Engineer, New Works, &c., the Tees Valley and Cleveland Water Board, Corporation Road, Middlesbrough, indicating the work in which they are interested, and enclosing a deposit of £5 5s. for each Contract. Cheques should be made payable to the "Tees Valley and Cleveland Water Board." The Deposit will be returned upon the submission of a bona-fide Tender.

Applicants for Tender documents will be notified of the last date for receipt of Tenders.

The Board invites these Tenders on a FIXED PRICE basis, that is to say, without the inclusion of cost variation for labour or materials.

The Board does not bind itself to accept the lowest or any Tender.

E. A. MORRIS,
Clerk of the Board
and Chief Executive Officer.
Water Board Offices,
G.P.O. Box No. 60,
Corporation Road,
Middlesbrough. E9256

METROPOLITAN WATER, SEWERAGE AND DRAINAGE BOARD, NEW SOUTH WALES, AUSTRALIA

JOB NO. 3389-W

TENDERS are invited for the MANUFACTURE, SUPPLY, TESTING and DELIVERY F.O.B. of approximately 100 miles of 4-inch nominal diameter, centrifugally spun, cement-lined or unlined, CAST IRON PIPES suitable for "push-in" rubber ring joints, with unlined cast iron bends, tees and hydrant tees, suitable for lead jointing.

Copies of the specification and Tender documents may be obtained on application to the Agent-General for New South Wales, 56/57, Strand, London, W.C.2.

Tenders must be delivered to the Secretary, Metropolitan Water, Sewerage and Drainage Board, 341, Pitt Street, Sydney, New South Wales, Australia, not later than 2 p.m. on Tuesday, 12th April, 1960. E9297

Classified Advts. continued on page 126

BOOKS and PUBLICATIONS

PITMAN technical books from all booksellers

PRINCIPLES OF ELECTRICITY & MAGNETISM
By Y. Rocard, translated by G. F. Herrenden-Harker

Here is the first English translation of this classic French work. Coming from a country where teaching is regarded as an art, it is based on a course given by Professor Rocard at the Sorbonne and covers the groundwork of the subject with exceptional concision and clarity. Price 70/- net.

FLUID PRESSURE MECHANISMS
By H. G. Conway, M.A., M.I.Mech.E., etc.

Second Edition.

This book deals with hydraulic and pneumatic machinery. It is not concerned with detailed design or constructional features, but with the essential principle of the various devices, how they work and how they differ from each other. The various devices have been classified, and nomenclature standardised. An extremely useful work for all engineers. Price 32/6 net.

POWER ECONOMY IN THE FACTORY
By J. C. Todman, F.C.W.A.

A reliable and up-to-date book for cost clerks, works accountants, engineers and business men, showing how running costs can be reduced and production improved, with indications of common faults in the organisation and operation of mechanical labour. Price 12/6 net.

Parker St., Kingsway, London, W.C.2.

Enter No. 1251 on reply card

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT BANGKOK, THAILAND

INVITATION FOR BIDS— NO. YS-2-18

The Royal Irrigation Department of the Kingdom of Thailand hereby invites SEALED WRITTEN BIDS for FURNISHING and DELIVERING the following GOODS, EQUIPMENT, and MATERIALS either f.o.b. Contractor's shipping point or c.i.f. Bangkok Wharf, Thailand, for the Bhumipol Power Plant, Yanhee Multi-Purpose Project, Kingdom of Thailand, in accordance with the Contract Documents, for furnishing :

TWO (2) 115 metric ton, single-trolley, motor-operated OVERHEAD TRAVELLING CRANES, each with a 20 metric ton auxiliary hoist, and complete with rails, catwalk and appurtenances.

ONE (1) 9 metric ton GANTRY CRANE, motor operated, complete with rails and appurtenances.

ONE (1) lot of draft-tube-gate-slot GRATINGS and FRAMES.

Invitations for Bids will be issued in April, 1960, and will be opened in June, 1960. Copies of Contract Documents, Invitation for Bids—No. YS-2-18, Overhead Travelling Cranes, Gantry Crane, Rails and Miscellaneous Metal Work, may be obtained by qualified Bidders on written request to :

Royal Irrigation Department, Attention : Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1901, South Navajo Street, Denver 23, Colorado.

Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $10.00 for each copy of the Contract Documents requested. The remittance is non-returnable.

M. L. XUJATI KAMBHU,
Director General.

Royal Irrigation Department,
Kingdom of Thailand,
Bangkok, Thailand. E9325

BRISTOL AVON RIVER BOARD

CONTRACT NO. 195

The Bristol Avon River Board invite TENDERS for Civil Engineering Works at AVON WEIR, Christian Malford, Nr. Chippenham, Wiltshire.

The works comprise the Construction of a Sluiceway to accommodate a 30ft. span by 8ft. deep Automatic Radial Gate together with Steel-Piled River Banks, Reinforced Concrete Access Bridge, Channel Excavation and Ancillary Works.

Applications for copies of the Specification, Bill of Quantities and Contract Drawings should be made to the undersigned.

Tenders duly sealed and endorsed "Contract No. 195" must be delivered to the Clerk of the Board at 18, Bennett Street, Bath, not later than noon on Thursday, 21st April, 1960.

F. GREENHALGH,
Engineer to the Board.

18, Bennett Street,
Bath. E9324

CITY OF MANCHESTER

DAVYHULME SEWAGE WORKS EXTENSIONS

TENDERS invited for the following :

(1) Provision and Erection of SPECIAL CAST IRON PIPEWORK and Erection of VALVES associated with Return Activated Sludge Pumping Station.

(2) Provision and Erection of 5-TON ELECTRICALLY OPERATED OVERHEAD CRANE for Return Activated Sludge Pumping Station.

Tender documents returnable by the 2nd May, 1960, from the City Surveyor, Town Hall, Manchester, 2. E9279

EDUCATIONAL

UNIVERSITY OF CAMBRIDGE

DEPARTMENT OF ENGINEERING

POST-GRADUATE COURSE IN STRUCTURES AND MATERIALS

The 1960-61 POST-GRADUATE COURSE IN THEORY OF STRUCTURES AND STRENGTH OF MATERIALS will be held in the Department of Engineering, Cambridge University, beginning on 5th October, 1960, and finishing in June, 1961.

The latest advances made in the understanding of the behaviour of metallic structures under static, repeated or fatigue loading will be the principal subject of the Course, with particular emphasis on welding as a method of fabrication. No attempt will be made to teach conventional methods of design, but present-day practice and possible future developments will form the subject of critical study.

The object of the Course is not to train research workers, but to help engineers to apply the latest advances in knowledge. The Course will include lectures, colloquia and laboratory work, and each student will be encouraged to make a detailed study of some problem of particular interest to him.

The Course is open to University Graduates with industrial experience, and to others with suitable equivalent qualifications and of sufficient experience to obtain full benefit from a post-graduate course.

Further details and forms of application for admission may be obtained from the Secretary, Cambridge University Engineering Laboratory, Trumpington Street, Cambridge. The completed forms of application should be returned to the Secretary not later than 31st May, 1960. E9275 E

EDUCATIONAL

COLLEGE OF AERONAUTICS

ONE-YEAR POST-GRADUATE COURSE IN FLIGHT CONTROL, 1960-1961

Applications are invited for the ONE-YEAR COURSE IN FLIGHT CONTROL which begins on 10th October, 1960. Prospective students must be of Graduate status in an appropriate branch of Science or Engineering, or have attended a preliminary one-year course at the College and, preferably, have had practical experience.

The purpose of the Course is to give instruction in the techniques employed in the automatic control of all types of flying machine.

Students who complete the course satisfactorily will be awarded the Diploma in Advanced Engineering (D.A.E.).

Further information and forms of application may be obtained from : The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E9262 E

COLLEGE OF AERONAUTICS

ONE-YEAR POST-GRADUATE COURSE IN CONTROL ENGINEERING, 1960-1961

Applications are invited for the ONE-YEAR COURSE IN CONTROL ENGINEERING which begins on 10th October, 1960. Prospective students must be of Graduate status in an appropriate branch of Science or Engineering, or have attended a preliminary one-year course at the College and, preferably, have had practical experience.

The purpose of the Course is to give instruction in the techniques employed in control engineering as applied in a wide range of industries.

Students who complete the course satisfactorily will be awarded the Diploma in Advanced Engineering (D.A.E.).

Further information and forms of application may be obtained from : The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E9261 E

A.M.I.MECH.E., B.Sc., City and Guilds, etc., Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A PROFESSIONAL ENGINEER

is required by the

ATOMIC ENERGY ESTABLISHMENT, WINFRITH, DORSET

to assist the Development Engineer in providing an engineering service to Industrial Chemists. The prime responsibilities are the treatment and disposal of radioactive wastes, comprehensive chemical services to reactor projects, and the development, commissioning and operation of new plant from basic requirements, involving close liaison with scientific staff.

Applicants should have served a recognised engineering apprenticeship, or have had equivalent training, and should be corporate members of a senior engineering institution, or have equivalent qualifications.

Experience in the design, layout and commissioning of chemical plant and the preparation of basic flow sheets and specifications is required.

Salary : In the range £860 (at age 25) to £1340 per annum.

Housing and superannuation schemes.

Send postcard for application form to Personnel Branch (W.249.25), U.K.A.E.A., A.E.E. Winfrith, Dorchester, Dorset, not later than April 20th, 1960.

E9250 A

A PUBLIC RELATIONS COMPANY requires a TECHNICAL WRITER familiar with the electrical and electronics industries. Background of electronic computers an advantage. This is a responsible position offering broad scope for advancement. Salary according to age and experience. Reply.—BOX No. E2772, "The Engineer." A

ASSISTANT ENGINEER for work in connection with site investigations and soil mechanics laboratory required immediately by Consulting Engineers, F. R. Bullen and Partners, Dacre House, Dean Farrar Street, London, S.W.1. E9260 A

ASSISTANT ENGINEER for Chemical and Metallurgical Plant Maintenance. Age 25 to 30. Engineering Degree or A.M.I.M.E. desirable and at least five years' practical experience in heavy industry required. Staff pension scheme. Five-day week.—Written applications to Personnel Officer (Staff), Magnesium Elektron Limited, P.O. Box 6, Lumm's Lane, Clifton Junction, Swinton, near Manchester. E9227 A

B.B.C. requires ENGINEER for Planning and Installation Department in London. He must be familiar with basic principles of structural steelwork design up to standard required for Associate Membership, Institution of Structural Engineers, and have practical experience in fabrication and erection of lattice steel structures. Work involves application of these principles and practice to extensive radio aerial systems in close co-operation with radio design engineers responsible for electrical performance of aerials. It offers scope for development of original ideas in use of new materials and methods in this field. Salary in scale £1230, with annual increments to maximum of £1580 per annum.—Requests for application forms to Engineering Recruitment Officer, Broadcasting House, London, W.1, quoting ref. EX.60.14.Eng. E9318 A

SITUATIONS VACANT

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

Two vacancies exist in a field of work connected with NIMROD—the 7GeV PROTON SYNCHROTRON now under construction for the NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE.

1. PROFESSIONAL ENGINEER (1626/25) required to initiate and operate a section arranging for :

(a) manufacture of a wide range of plant and equipment either by contract or within the NIMROD Workshop facilities.

(b) Services required for inspection and maintenance of specialist installations.

A broad engineering background combined with experience in contract procedure and specification writing is essential.

Salary : £1370 to £1825 p.a.

2. ENGINEERING TECHNICIAN (1627/25) to assist the professional engineer in the above duties.

Applicants should have served an engineering apprenticeship or have had equivalent training and have had considerable experience of workshop practice. O.N.C. in Mechanical or Electrical Engineering would be an advantage and some knowledge of contract procedure and specification writing desirable.

Salary : £925 (at age 30 or over) to £1105 p.a.

Housing and Superannuation schemes.

Please send Postcard for details and application form (quoting appropriate reference number) to Group Recruitment Officer, U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

E9251 A

CHIEF INSPECTOR required by large excavator manufacturing firm of some 3000 employees. Applicants must have served an engineering apprenticeship and have an "inspection" experience, dealing with machine shops, fitting and erecting, fabricating and finishing departments. Successful candidate will be required to take eventual charge of an Inspection Department consisting of 42 inspectors.—Applications in writing, giving all relevant particulars, e.g. experience, education and approximate salary, to Industrial Relations Department, Ruston-Bucyrus, Ltd., Excavator Works, Lincoln. E9243 A

CHIEF PRODUCTION ENGINEER

MAVOR AND COULSON of GLASGOW require a Chief Production Engineer to take charge of established department responsible for Methods, Planning of Work, Jig and Tool Design and Rate-fixing. This is an important post requiring wide knowledge of modern engineering practice and offering considerable scope to successful applicant. Initial salary commensurate with experience. Contributory Superannuation Scheme.—Details of qualifications, experience and salary expected, to Works Director, Mavor and Coulson, Ltd., Bridgeton, Glasgow, S.E.

E9265 A

DESIGNER-DRAUGHTSMAN. Applications are invited from men under 40 years of age who were apprentice trained, hold H.N.C. (Mechanical) or equivalent and have experience of problems involving industrial steam applications, piping and pumping systems. H.N.C. endorsement for Heat Engines, Applied Thermodynamics or Steam Engineering is desirable. The appointment is permanent and pensionable ; 5-day, 40-hour week ; 3 weeks' annual holiday ; good working conditions. Assistance with housing given when necessary and pending removal, a tax-free allowance of £4 per week is paid to married recruit. Company pays cost removal. —Please write to SP.A. Dept., MICHELIN TYRE CO., LTD., STOKE-ON-TRENT, Staffs, quoting Ref. B/512/E.

E9271 A

DESIGNER DRAUGHTSMEN for press tools, with opportunity to work on special purpose machines. Progressive company in S.W. London area ; permanent situation with pension scheme for suitable applicants. Salary range £900 to £1000 per annum. Apply, giving age and details of experience.—BOX No. E2768, "The Engineer." A

DIESEL ENGINEERS

Sales and Contracts Engineers, aged up to 35. O.N.C./H.N.C. in Mechanical Engineering or equivalent ; Diesel background essential, preferably with apprenticeship ; Sales or Contracts experience in Industrial, Marine Traction definite advantage.

Fully detailed applications in confidence to Personnel Manager,

Davey, Paxman and Co., Ltd.,
Standard Ironworks, Colchester.

E9308 A

DRAUGHTSMAN (age 25/30) required for varied Chemical Plant Development work. H.N.C. (Mechanical) and knowledge of plant layout and pipe work essential. Permanent and progressive post. Superannuation and profit sharing schemes. —Applications to : Personnel Manager, F. W. Berk and Co., Ltd., Canning Road, Stratford, E.15.

E9218 A

DRAUGHTSMAN required for work on valve design. Good working conditions, pension scheme, &c. All applications will be treated in confidence.—Apply in writing to Chief Engineer, Alley and MacLellan Ltd., Bromyard Road, Worcester, quoting newspaper reference number. E9263 A

SITUATIONS VACANT

DRAUGHTSMAN

Applications are invited for the above post, which is located in Birmingham.

The work is interesting and varied and is mainly in connection with the design of industrial heating equipment. A knowledge of combustion technique and the use of refractories would, therefore, be an advantage.

Candidates should possess the Ordinary National Certificate in Mechanical Engineering as a minimum qualification.

The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £733–£853 per annum.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston Birmingham, 15. E180 A

DRAUGHTSMEN

There are several vacancies in the Design Office of the Central Engineering Establishment of the National Coal Board, Stanhope Bretby, Nr. Burton-on-Trent.

The work of this new Establishment involves the design and development of many new kinds of equipment for the mining industry and is, therefore, stimulating and of great interest.

Applicants should have a sound engineering background and possess H.N.C. or equivalent.

The vacancies occur in the following grades :—Section Leader : up to £1400 p.a. (X.1612.3F). Senior Engineering Draughtsmen : up to £1065 p.a. (X.1613.3F.).

There are attractive conditions of service, including superannuation. Applications, giving full details of age, qualifications and experience, should be sent to the Administrative Officer (quoting relevant number) at the above address, before 8th April, 1960.

E9313 A

ENGINEER, with H.N.C. or equivalent, and preferably with basic electrical knowledge, to undertake interesting experimental work on Mechanical and Heat Transfer Tests in Research and Development Department.—Reply, stating age, qualifications and salary required to Personnel Manager, The Superheater Co., Ltd., Ashburton Road, Trafford Park, Manchester, 17. E9216 A

ENGINEERING ASSISTANT required for work in Southampton Docks at a starting salary of £990 per annum to a maximum of £1034 per annum. Applicants should preferably have had experience in the design of dockside or similar structures and buildings in steel and/or plain and reinforced concrete.—Applications, stating age, qualifications, &c., should be addressed to the Chief Docks Engineer, British Transport Commission, Herbert Walker Avenue, New Docks, Southampton. E9298 A

ENGINEERING DESIGNER required for senior position by expanding vertical Textile combine in Nottingham. Textile engineering experience, mainly in dyeing and finishing, desirable. Interesting position with original development and designing work in yarn processing, synthetic fabric knitting, dyeing, finishing and making-up. Salary commensurate with knowledge, ability and initiative. Contributory pension scheme.—Jersey Fabrics Limited, Alfreton Road, Nottingham. E2770 A

ENGINEERS. TECALEMIT, LIMITED, PLYMOUTH, invite applications from Engineers, age 20 to 30, minimum qualifications Graduate I.Mech.E., to be trained as specialists in various Departments. —Full details of training and experience to Personnel Manager. E9266 A

ENGINEERS (qualified) with full experience of construction of pipelines, pump stations and tank farms, required for Middle East by important international firm.—Write to BOX No. 3271, c/o Charles Barker and Sons Limited, Gateway House, London, E.C.4. E9315 A

FIRST-CLASS DESIGN AND DETAILING DRAUGHTSMAN

required for progressive company dealing with the manufacture of Automatic Control Devices for Domestic Appliances.

Applicants must be familiar with layout and detailing of light electro-mechanical mechanisms for quantity production.

Four-figure salary offered according to qualifications and experience.

Factory located in North-West London district.

First-class working conditions. Voluntary Pension Scheme.

Write in the first instance to BOX FC. 3067, A.K. Advtg., 212a, Shaftesbury Ave., LONDON, W.C.2. E9323 A

FULLY QUALIFIED ENGINEER to be directly responsible to the Partners, required by medium-sized firm of Consulting Engineers in Westminster. Should have had varied civil and structural engineering experience, including road, bridge and railway works. Age 35-45.—BOX No. E9199, "The Engineer." A

GRADUATE ENGINEER required by Research Association in Leeds, to lead small team on applied research. Young men seeking responsibility should write.—BOX No. E2771, "The Engineer." A

SITUATIONS VACANT

MECHANICAL DESIGNERS for automatic production and assembling machines and mechanical handling of piece parts; also food and chemical process plant. Varied projects need ingenuity and enthusiasm. Good salary.—Rhoden Partners, 19, Fitzroy Square, W.1 (EUSton 9696). E9309 A

MECHANICAL OR ELECTRICAL ENGINEER

Are you a very well-qualified young professional Engineer of outstanding ability and potential for development ? If you are and, in addition, are enthusiastic and prepared to work on maintenance and plant installation work with a view to progressing up the ladder as fast as your abilities permit, then we should like to offer you a job. Write to our Personnel Manager and tell him all about yourself and what you have done in the past. His address is Tubes Limited, Rocky Lane, Aston, Birmingham, 6.

E9311 A

METALLURGIST urgently required. This is a new opening in a rapidly expanding company and would suit a person of L.I.M. or equivalent standard. —Write to Manager, Pollard Bearings (Northampton), Ltd., Countess Road, Northampton, giving full details. E9289 A

NUCLEAR ENGINEERING

ENGINEERS required for design and development work on heat exchangers, steam generators, pressure vessels and other components associated with advanced types of nuclear reactors and with other advanced systems in the power and propulsion field. Applicants should hold a Mechanical or Chemical Engineering Degree and should preferably have some previous experience in design or development of heat exchangers and high pressure steam plant. Commencing salary in range £900–£1450 per annum, according to experience. Contributory Pension Scheme.—Application should be made in writing, giving details of age, qualifications and experience, to :

Staff Manager,
FOSTER WHEELER LIMITED,
3, IXWORTH PLACE,
LONDON, S.W.3.

E9234 A

PILKINGTON BROTHERS LIMITED require TWO MECHANICAL ENGINEERING DRAUGHTSMEN for design work on automatic machines for handling and cutting flat glass.

Age range 22–35.

Qualifications : H.N.C. desirable and some experience in the design of light to medium automatic machinery an advantage.

Five-day week, assistance with house purchase, recreation and canteen facilities, superannuation scheme.

Applications should be addressed to Group Staff Department, Pilkington Brothers Limited, Head Office, Grove Street, St. Helens, Lancashire. E9277 A

PROJECT ENGINEER (aged 28-35 years), required by major contractors in the Petroleum and Chemical field for their London offices. The work involves broad direction of projects through the engineering and draughting phases, maintenance of close liaison with customers' engineers and general co-ordination of material procurement activities. Minimum qualification is A.M.I.Mech.E. Preference for man with B.S.C (Eng.) or A.M.I.Chem.E.—Write fully, stating age, qualifications and experience, to : Staff Manager, Foster Wheeler Limited, 3, Ixworth Place, London, S.W.3. E9282 A

REQUIRED TO TRAIN AS TECHNICAL REPRESENTATIVE, young man 20-21 years of age, sound education, preferably board school. Previous experience not essential, but engineering background an advantage. Successful applicant would first undergo training at our Head Office, Stafford, for a period of six months and later be located as a junior Technical Representative. The position carries salary, commission, car and out-of-pocket expenses and the Company operate a contributory superannuation scheme.—Apply in writing to the Weldmesh Sales Director, The B.R.C. Engineering Company, Stafford ; giving details of age, education, experience, including information as to whether eligible for National Service. E9196 A

WANTED. ASSISTANT POWER STATION SUPERINTENDENT, experienced in running and maintaining Steam Plant with Factory Equipment including 700kW Fraser and Chalmers Condensing Turbo Set with Babcock and Wilcox Watertube Boiler for works in the Gambia, West Africa. State experience and salary required.—BOX No. E9272, "The Engineer." A

WANTED. POWER STATION SUPERINTENDENT experienced in running and maintaining Steam Plant with Factory Equipment, including 700kW Fraser and Chalmers Condensing Turbo Set with Babcock and Wilcox Watertube Boiler for works in the Gambia, West Africa. State experience and salary required.—BOX No. E9273, "The Engineer." A

SITUATIONS VACANT

RICHARD THOMAS AND BALDWINS LIMITED

TECHNICAL STAFF

FUEL ENGINEERS

Fuel Engineers are required to be based at the Company Central Engineering Department, Spencer Works, Llanwern, Newport, Mon., for work in connection with new projects at the Company's works, but particularly with the new fully integrated works under construction at Llanwern. Applicants must have extensive experience of fuel technology as applied to iron and steel production, with particular reference to gas distribution control, steam production and distribution, and to furnace practice. A sound technical education is required.

INSTRUMENTATION ENGINEERS

Instrumentation Engineers are required in the Company Central Engineering Department mentioned above, for work in connection with preparation of, and supervision of, installation of instrumentation schemes at the Company's works, in particular at the new Spencer Works at Llanwern, near Newport, Mon.

Applicants should be thoroughly familiar with the application of modern techniques and equipment to iron and steel production processes.

Salary scales commensurate with qualifications and experience.

Contributory Staff Pension and Life Assurance Scheme.

Applications in confidence should be addressed to

The General Manager—Engineering,
Company Central Engineering Department,
Spencer Works,
Richard Thomas and Baldwins Limited,
Llanwern, Newport, Mon.

the envelope to be endorsed "Fuel Engineer" or "Instrumentation Engineer" as appropriate, in top left-hand corner.

E9267 A

TECALEMIT LIMITED, PLYMOUTH, DEVON have a vacancy for a SENIOR ASSISTANT in the Physical Laboratory of the Research Department.

The work involves research and control on non-metallic materials such as filter media, plastics, rubber and adhesives.

Applicants should have a University Degree in Mechanical Engineering or equivalent qualification, with an interest in physics or technology ; research experience with one of the materials mentioned and some experience in statistics as applied to planning and evaluating experimental work will be an advantage.

The finally selected candidate will find interesting and varied work as the leader of a team in a progressive and active modern factory. His salary will be commensurate with his qualifications and experience.

The Company operates a contributory superannuation and life insurance scheme.

Applications should include details of age, education and experience, and be addressed to the Employment Officer.

E2750 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, "The Engineer." A

YOUNG QUALIFIED ENGINEER required to manage a new factory opening shortly in Bedfordshire ; experience of fully automatic production of light engineering assemblies an advantage. Good prospects. Write fully.—BOX No. E9270, "The Engineer." A

CONSETT IRON COMPANY LIMITED

invite applications from

PLANT ENGINEERS

A qualified Plant Engineer is required to supervise maintenance at the Jarrow Basic Brickworks, where a variety of high-grade refractories is produced. The plant and equipment includes crushers, conveyors, mixers, hydraulic presses, tunnel kiln and mechanical handling equipment.

The Company operates an attractive pension scheme and assistance with housing may be given.

Please write to the Personnel Manager, Consett Iron Company Limited, Consett, Co. Durham, giving details of age, education, qualifications and career to date.

All applications (quoting Ref. No. 60/E/2) will be acknowledged and will also be treated in strict confidence.

E9253 A

SITUATIONS VACANT

Wilmot Breeden

PROCESS PLANNING ENGINEERS

Applications are invited for the above posts from men who are seeking positions with a well-established Company. Preference will be given to men who have :—

1. Sound knowledge of presswork techniques.
2. At least O.N.C. in Mechanical Engineering.
3. Have served a recognised apprenticeship.

In return the Company offer :—

1. Attractive salary.
2. 5-day week.
3. Excellent pension scheme.
4. Good canteen and sports and social facilities.

Applications should be made, in writing in the first instance, to the

PERSONNEL MANAGER, WILMOT BREEDEN LTD. GOODMAN STREET, BIRMINGHAM, 1.

E9307 A

SITUATIONS VACANT

FLEMING BROTHERS

(Structural Engineers) Ltd.

invite applications for the position of :—

TECHNICAL DIRECTOR

Applications are invited for this important appointment which calls for a man of proven ability in the Structural Engineering field, who is fully conversant with modern developments in the design of Steel Structures.

Preferably, he should be qualified to A.M.I.Struct.E. level or a University Graduate and be confident about leading a team of first-class Technicians in an expanding group of Companies. A generous salary and entry into a Top Hat Pension Scheme is offered.

Applications will be treated in the strictest confidence. These should be marked "Strictly Private" and addressed to :—

THE MANAGING DIRECTOR,
Messrs. Fleming Bros.
(Structural Engineers) Ltd.,
Stanchion House,
1, Park Gardens,
GLASGOW, C.3.

E9302 A

R. SILCOCK & SONS LTD.

Manufacturers of Animal Feedingstuffs

wish to appoint a

DEPUTY CHIEF ENGINEER

Applications are invited to fill this senior managerial vacancy at the Company's Headquarters in Liverpool. The position carries with it excellent prospects for advancement. The successful applicant will be required to understudy and deputise for the present Chief Engineer, who retires in a few years.

The work covers both maintenance and new installations at five modern and highly mechanised factories, situated at Liverpool, London, Bristol, Hull and Glasgow. Good academic and professional qualifications, and proved administrative ability are essential. Preferred age 35 to 45. A substantial salary is offered for this responsible position, together with membership of a comprehensive contributory pension scheme, including generous cover for dependants.

Applications, giving details of age, education, qualifications and experience, will be treated in strict confidence and should be addressed in an envelope marked "PRIVATE" to the Senior Personnel Manager.

R. SILCOCK & SONS LTD.,
56, Great Howard Street, Liverpool, 3. E9303 A

SENIOR PROJECT ENGINEER

to take charge of a major development project designed to manufacture for a new and expanding market. The project forms part of the diversification plan of a large producing Company with headquarters in the North-West and associated with the chemical industry. Initial salary £1750–£2250 p.a., with pension scheme and distinct prospects of rapid advancement.

Principal initial task will be to ensure that schedules of all civil and mechanical engineering work on the project are maintained. This will involve close liaison with the Chief Engineer (to whom the Senior Project Engineer will be directly responsible), sub-contractors, &c. On completion of contracting and engineering work, the Senior Project Engineer will assist in bringing the plant into operation in conjunction with the Production Manager. On successful execution of this assignment, the Senior Project Engineer can expect to be appointed as Assistant Chief Engineer of the Group at an appropriate salary.

Qualifications desired are previous successful project engineering experience, preferably covering both mechanical and chemical engineering. Should also have appropriate professional qualifications allied with a background of progressive management and the potential to grow with an expanding organisation.

Please write briefly in first instance, quoting Reference No. 654, to :—

AA LTD

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E9299 A

CAREERS IN SIGNAL ENGINEERING

British Railways, Southern Region, have vacancies in the Drawing Office of the Signal Engineer's Department at Wimbledon for suitable men. Modern development and expansion now taking place in railway signalling offer interesting work with excellent prospects of advancement.

Suitable candidates will be engaged as trainees and given a three months' training followed by a qualifying examination.

Successful students will be engaged on circuit design and the preparation of drawings for signalling or telecommunications work.

The qualification required is Ordinary National Certificate in Electrical Engineering, or equivalent.

Drawing Office, or railway experience, is desirable but not essential.

The present rates of pay in the Drawing Office vary from £363 per annum at age 18 to £1034, and the rate of pay during training and in the initial grade to which successful candidates will be appointed will be from £363 per annum at age 18 to £801 per annum at age 32.

Additional pay for certain qualifications.

Encouragement will be given to successful candidates wishing to obtain Higher National Certificate in Electrical Engineering.

Thirty-eight-hour, five-day week.

Pay for overtime.

Free residential travel within limits, and certain free and reduced rate railway travel facilities provided.

Write to :— **THE SIGNAL ENGINEER,**
BRITISH RAILWAYS, SOUTHERN REGION,
WIMBLEDON STATION,
LONDON, S.W.19. E9295 A

Classified Advts. continued on page 128

SITUATIONS VACANT

Required

PLANT AND MACHINERY VALUER

Must be fully experienced and able to work without supervision. Permanent post, Pension Scheme. 5-day week. Full particulars in confidence to

LEOPOLD FARMER AND SONS,
46, Gresham Street, London, E.C.2.
Tel : MONarch 3422 (8 lines)

E9296 A

SITUATIONS VACANT

PRODUCTION CONTROL

Applications are invited for a Senior position as PRODUCTION CONTROLLER, with direct responsibility to the Works Director.

The appointment is in a Medium/Heavy Engineering concern about 40 miles from London, engaged in batch production of heavy equipment.

Salary not less than £1750 p.a. but in advance of this figure according to the experience of the candidate. Assistance can be offered with housing arrangements.

Applicants should have had a sound technical education, preferably to degree standard, followed by a thorough engineering training and recent experience in Management.

Preferred age group 35-45.

Applications, in confidence, to BOX No. E9284, " The Engineer." A

SITUATIONS VACANT

DESIGN STAFF

required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, PRODUCTION GROUP,

for the Fuel Element Inspectorate Design Office.

This Inspectorate is responsible for the detailed design and inspection of Fuel Elements manufactured at the Authority's Springfields Works for the National Nuclear Power Programme, for export reactors and for the Authority's own reactors. At present the Inspectorate is located at Risley, near Warrington, Lancs., but it is possible that in 18 months to 2 years' time it will be transferred to Springfields Works, Salwick, Nr. Preston, Lancs.

DUTIES : To lead teams of Assistant Design Engineers and Draughtsmen engaged in the design of fuel elements.

The duties will include the assessment of preliminary designs prepared by reactor designers and the development of production designs to meet the requirements for economic manufacture and extreme reliability in service.

The design teams will be responsible for preparation of manufacturing drawings and technical specifications for fuel elements and their components, and also, in co-operation with Commercial Directorate, for the programming and ordering of fuel element components to meet the Authority's manufacturing programme.

QUALIFICATIONS AND EXPERIENCE : Applicants must have served a recognised engineering apprenticeship and be corporate members of a Senior Engineering Institution, or hold equivalent qualifications, and have had considerable design experience in precision work for batch production. Shop experience in this field in tool-making would be an advantage.

SALARY : Within the ranges £1370–£1825 and £1880–£2180, according to qualifications and experience.

Contributory Superannuation. Staff housing scheme.

Send postcard for application form, quoting reference P.137.JI, to Staff Officer, United Kingdom Atomic Energy Authority, Production Group Headquarters, Risley, Warrington, Lancs.

Closing Date: 31st March. 1960.

E9254 A

SITUATIONS VACANT

MECHANICAL ENGINEERS

An expanding Company operating on a continuous process basis has vacancies for two well qualified Mechanical Engineers in London and South Wales. Applicants should have sound experience in heavy engineering, and in addition to their technical qualifications should have attained a good level of general education. The age limit is 32 and an attractive commencing salary is being offered.—Write, stating brief details to BOX No. E9320, " The Engineer."

A

AEI

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED
TURBINE GENERATOR DIVISION

DESIGN AND DEVELOPMENT ENGINEERS

A policy of expanding technical development has created a number of vacancies for Design and Development Staff in the following departments in the Turbine-Generator Division, Trafford Park, Manchester.

LARGE STEAM TURBINES
SMALL STEAM TURBINES
LARGE GENERATORS
MECHANICAL DEVELOPMENT

Applications are invited from Engineers who are graduates or who possess a Higher National Certificate, and who have had experience in the design of high-speed rotating machinery. Previous experience on steam turbines or generators would be an advantage.

There are rewarding opportunities for men with the right qualifications who are prepared to tackle interesting and challenging problems in these fields.

Please write for an appointment, giving brief details of qualifications and experience, quoting reference Z.14 to :

The Personnel Manager,
Associated Electrical Industries (Manchester), Ltd.,
Trafford Park,
Manchester, 17.

E9283 A

ENGLISH ELECTRIC

require

DRAUGHTSMEN

for one of their London Drawing Offices, concerned with general engineering projects, such as power station layouts and pipework.

There is also a vacancy for a

CIVIL ENGINEERING DRAUGHTSMAN

with a knowledge of general civil engineering and building practice.

Applicants must have had previous D.O. experience in this type of work and preferably possess a minimum qualification to O.N.C. level.

The D.O. is situated in Victoria, and these positions are permanent and pensionable after a qualifying period. Canteen facilities.

Please write in confidence to Central Personnel Services, Marconi House, 336/7, Strand, London, W.C.2, quoting reference E599.S.

E9287 A

ENGLISH ELECTRIC

have vacancies at

HINKLEY POINT NUCLEAR POWER STATION

for the following :

(*a*) **ELECTRICAL ENGINEER** who must have had a sound theoretical training in electrical engineering and preferably experience in the erection of electrical plant as installed in modern power stations.

(*b*) **MECHANICAL ENGINEER** who should have preferably had wide experience in construction engineering and or plant installation. A good theoretical training is essential.

The successful candidates for the above positions will join a team engaged in the co-ordination and inspection of work done by contractors, and preference will be given to applicants who have had experience in similar appointments.

Please write in confidence stating age, qualifications, past experience and present position to the

Group Resident Superintendent, Hinkley Point,
C/o Dept. C.P.S., Marconi House,
336/7, Strand, London, W.C.2,

quoting reference E.1816F.

E9288 A

SENIOR MECHANICAL ENGINEER

A senior Mechanical Engineer is required by a Company engaged in a continuous process industry. The successful candidate will become a member of a management team connected with the management of a large factory. It is essential that candidates have :

(a) A good Degree in Mechanical Engineering.
(b) Some background in heavy Engineering.

This vacancy is a particularly attractive one for the right calibre person and the future holds out very good prospects. The age limit is 35.

A good commencing salary is offered and write stating full details, age, qualifications and experience, to

BOX No. E9321, " The Engineer."

A

A large copper mine in the

RHODESIAN SELECTION TRUST GROUP

requires a

SENIOR ELECTRICAL ENGINEER

Applicants should hold a degree in Electrical Engineering and have had subsequent experience in heavy engineering work. They should preferably be under 35 years of age.

Duties will consist of planning engineering projects of a varied nature in connection with large scale mining operations including power generation and distribution, mine shafts and haulage, ore treatment, smelting and other associated heavy engineering plant.

Basic starting salary from £1750 p.a. depending on qualifications and experience. There is also a bonus scheme, at present paying 33 per cent on basic pay, and a variable cost of living allowance, currently £65 p.a. The company has generous pension, life assurance and medical schemes, and it also operates share purchase and house purchase arrangements.

Leave at 51 days p.a. may be accumulated over three years' service.

The outward passages for the employee and his family would be paid by the company.

Full particulars covering age, qualifications and experience should be sent in confidence to :

The Overseas Personnel Officer,
SELECTION TRUST LIMITED,
Mason's Avenue,
Coleman Street,
London, E.C.2.

PLEASE QUOTE R.7/E

E9286 A

SITUATIONS VACANT

CHIEF INSPECTOR

required by a Company specialising in the grinding and manufacture of the highest quality Gearing and Production of Machine Tools and Measuring Instruments. Qualifications required include full experience of the latest gear measuring and inspection techniques together with knowledge of A.I.D. procedure. This position, which includes responsibility for an up-to-date Gearing Standards Room is a permanent one, offering much interest to the successful applicant and comes within the scope of the Company's Superannuation Scheme.—Applications should be made, giving full particulars of experience, &c., to Company Secretary, The Gear Grinding Co., Ltd., Cranmore Boulevard, Shirley, Solihull, Warwickshire.

E9202 A

SITUATIONS VACANT

ELECTRICAL DESIGN ENGINEER

A Graduate is required for the position of Electrical Design Engineer at this fully integrated Iron and Steel Works situated on the West Coast of Cumberland.

The work is extremely varied ranging from High Voltage Power to Control Engineering.

Good Life Assurance and Contributory Pension Scheme.

Applicants, who should have had practical experience subsequent to a recognised training scheme, should write to The Secretary, Workington Iron & Steel Company (a Branch of the United Steel Companies Limited), Moss Bay, Workington, Cumberland.

E9222 A

SITUATIONS VACANT

BRITISH TRANSPORT DOCKS

invite applications for the position of

NEW WORKS ASSISTANT

in the Docks Engineer's Office, Garston Docks.

Applicants should have experience in the design, execution and maintenance of civil engineering works and knowledge of specifications and quantities. Associate Membership of the Institution of Civil Engineers desirable. Commencing salary £1045 per annum. Contributory superannuation scheme and certain rail travel facilities.

Applications, giving age, experience, qualifications and present position, should be forwarded to : Staff and Establishment Officer, British Transport Docks (E), 163, Euston Road, London, N.W.1, to arrive not later than Wednesday, 30th March, 1960.

E9291 A

AEI

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

TURBINE-GENERATOR DIVISION

SALES ENGINEERS

are required at Trafford Park, Manchester, to expand sales and prepare tenders for Gas Turbines and for Condenser and Heat Exchange Equipment.

A Degree or H.N.C. qualification or equivalent in Mechanical or Electrical Engineering is desirable. Applicants with experience of the design, operation or testing of gas turbines, steam turbines and/or associated heat exchange equipment are preferred. Some commercial experience would be an advantage.

Attractive salaries will be offered to applicants with the right experience. The Company provides a first class pension scheme and other benefits.

Please write for application form quoting reference L.14 to the :

Personnel Manager,
Associated Electrical Industries (Manchester), Ltd.,
Trafford Park,
Manchester, 17

E9252 A

SENIOR BUYER

A senior appointment in the buying field exists with a major industrial company with its Head Offices in London. Applicants should have a wide and varied experience of buying in the engineering industry and be capable of negotiating at management level. The need is for a good calibre man aged up to 35. Future prospects are extremely bright for a candidate with the right potential.

Write, stating full particulars to

BOX No. E9319, "The Engineer."

A

TECHNICAL SALES REPRESENTATIVE

Applications are invited for the post of Technical Sales Representative with a leading firm of pipeline valve manufacturers.

Applicants should be between the ages of 27 and 35 and have a good engineering background up to H.N.C. level. Previous sales experience is very desirable : initiative, a good personality and the ability to work without direct supervision are essential. This is a responsible position and the successful applicant would represent the Company in an established sales area within England and Wales.

Remuneration would be by salary, plus expenses, and a Company car would be provided.

The Company offers first class conditions of employment and housing assistance would be given if necessary.

Applications quoting reference TSR/TE, giving age, brief details of education and professional qualifications, previous experience and present salary should be sent to :

Home Sales Manager,
Audley Engineering Company Limited,
Newport,
Shropshire.

E9285 A

DESIGN ENGINEERS

required for interesting and varied work in connection with special purpose machinery and structures in the medium/heavy range.

Applications are invited from candidates aged 26–35, preferably qualified to A.M.I. Mech.E., but H.N.C. with suitable experience acceptable. These are permanent and progressive positions with attractive salaries. The Works are pleasantly situated within 15 minutes bus ride of Ipswich. Good canteen facilities and contributory Pension Scheme. Holiday arrangements respected.

Write, giving full details of age, qualifications, experience and salary required, to :

The Personnel Officer,
THE BRITISH STEEL PILING COMPANY, LTD.,
Zenith Works, Claydon,
Nr. Ipswich, Suffolk.

E9278 A

Development Engineer

aged 30-40, required for a substantial and rapidly growing concern in the heavy chemical field located in the North of England.

A good Engineering Degree is essential, together with experience in experimental and development work in medium engineering associated with chemical plants. A good knowledge of handling of corrosive liquids and gases and thermodynamics is also required. Those unable to satisfy these requirements need not apply.

The successful candidate will be expected to deal with specific technical problems and will be required to suggest and study new developments and practices.

This is a responsible position for which a commensurate salary will be paid.

A sound non-contributory Life Assurance and Pension Scheme is in operation. Bonus Scheme. Housing assistance to married men. 5-day week.

Applications giving full details, i.e. age, education, and experience should be addressed to BOX No. E183, "The Engineer."

A

SITUATIONS WANTED

DRAUGHTSMAN, General, desires post (part-time). Kent or London.—BOX No. E2775, "The Engineer." B

KEEN YOUNG MAN with engineering background and capital, seeks Working Partnership in established and reputable firm.—BOX No. E2776, "The Engineer." B

BUSINESSES and PREMISES

BERMONDSEY, LONDON, S.E. 33,000 sq. ft. Main road FACTORY & WAREHOUSE premises ; front offices 2500 sq. ft. Modern north-light factory 12,500 sq. ft. Storage of 18,000 sq. ft. Plus open land of 16,000 sq. ft. RENT £6000 p.a. exclusive.

GRAVESEND, KENT. 34,500 sq. ft. HEAVY STEEL WORKS, with 5- and 10-ton overhead travelling cranes ; lofty headroom, good loading. Plus wharf side open storage of 16,000 sq. ft. Modern office block. FREEHOLD £57,000.

CHAMBERLAIN & WILLOWS,
23, Moorgate, E.C.2.
(MET 8001.) E9290

SUB-CONTRACTING

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Classified Advts. continued on page 130

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		Main Location	*Auctioneers*
March 30	Miscellaneous stores and machine tools.	Northern Command Ordnance Sub-Depot, **Barlow, Nr. Selby, Yorks.**	**BARTLE & SON** (Dept. L), 50-52, Merrion Street, Leeds, 2. (Tel.: 2.0898).
	Textiles; tentage; blankets; canvas; webbing; cordage; haversacks; kitbags; groundsheets; drawers; vests; shirts; pullovers; old batteries and tyres; cable; tool kits; hand tools; furniture; paint; universal milling machine; grinding machines; boring and surfacing lathe; surfacing planing and thicknessing machine; etc.		
April 8	Miscellaneous stores.	Returned Stores Group, Reed Hall, **Colchester, Essex.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
April 21	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, **Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
May 3	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Royal Arsenal, **Woolwich, London, S.E. 18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
May 10	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, **Byley, Nr. Middlewich, Cheshire.** (Sale at Cheetham Town Hall, Manchester, 8.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)

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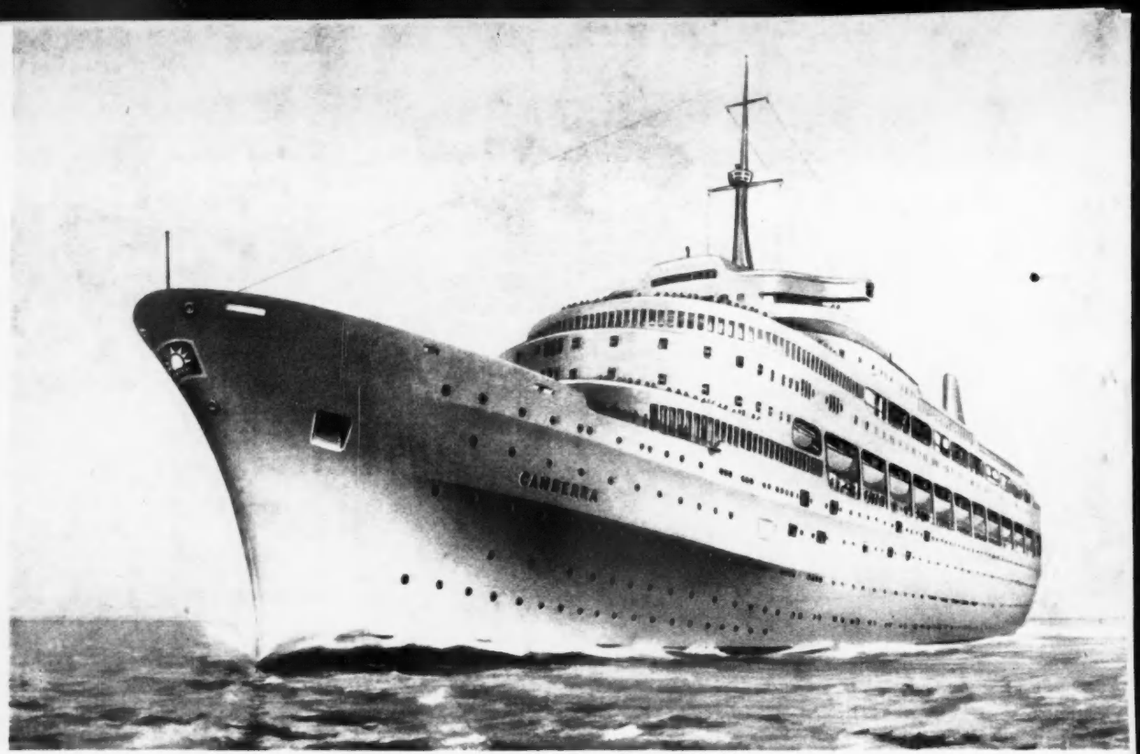

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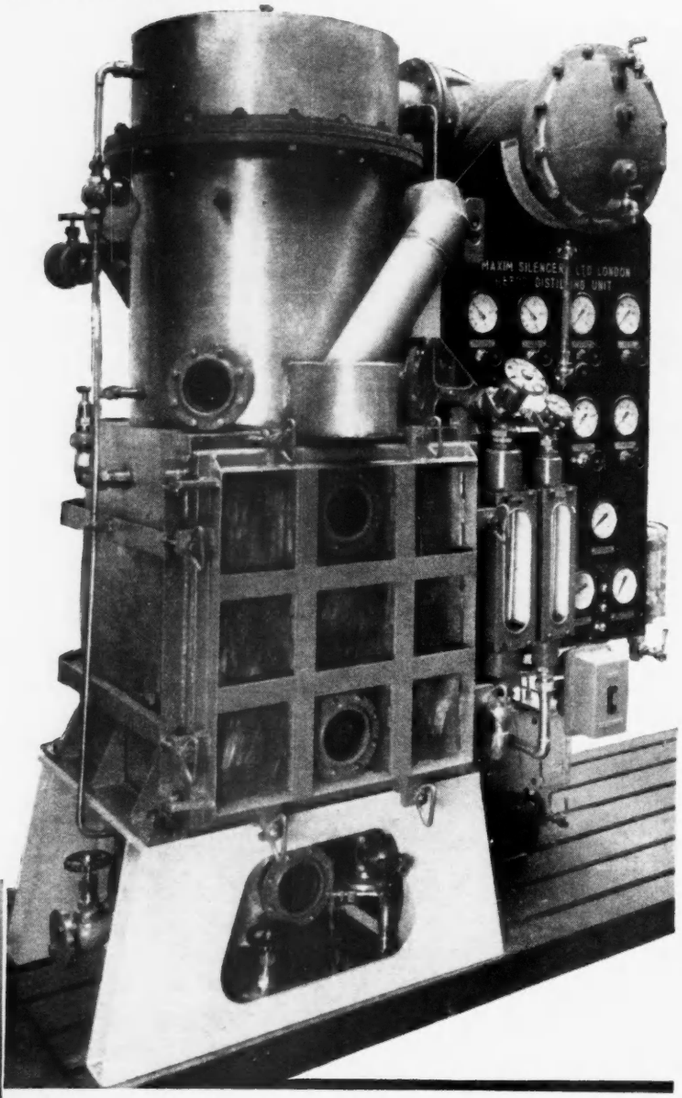
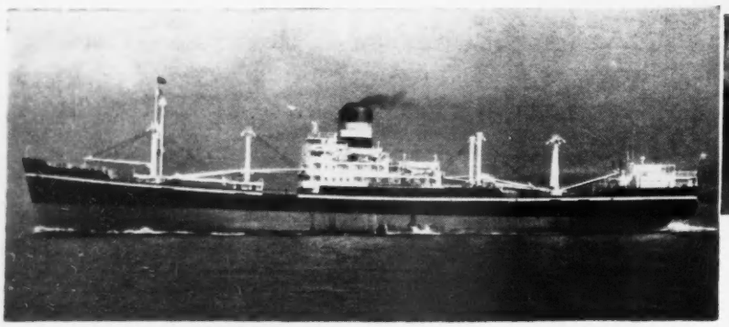


(Above) This Maxim L120D Unit gives an output of 37 tons of fresh water daily. Monel is used for the evaporator shell and the heating element to withstand boiling brine, waste steam heating and "cold shock" treatment.



(Left) The M.S. "Maturata" (7365 tons gross), Messrs. Thos. & Jno. Brocklebank Ltd., which is fitted with Maxim distilling equipment.

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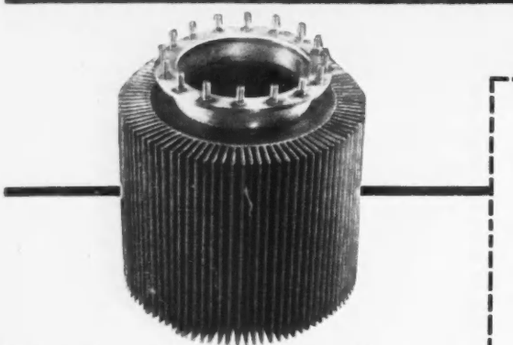

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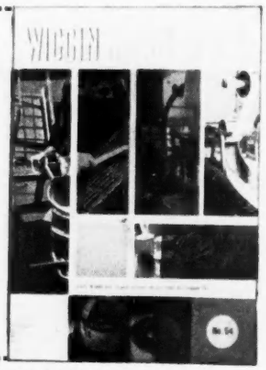

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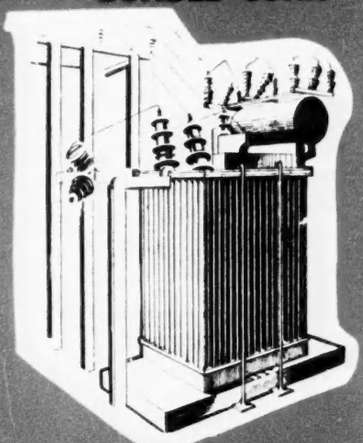

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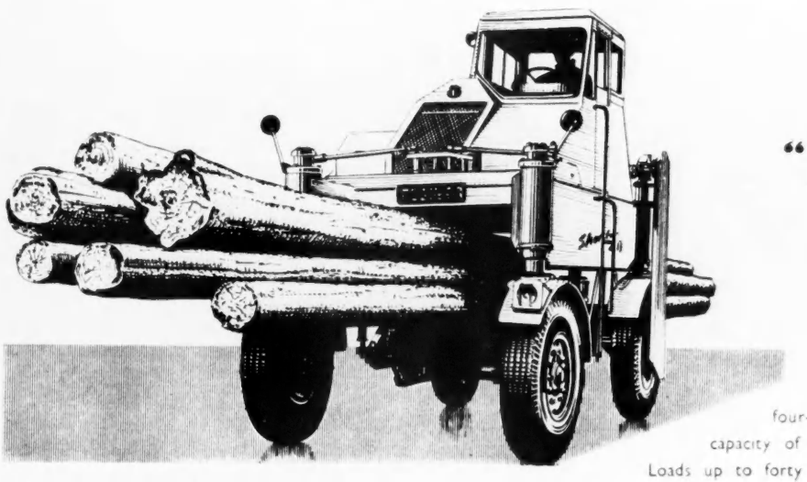

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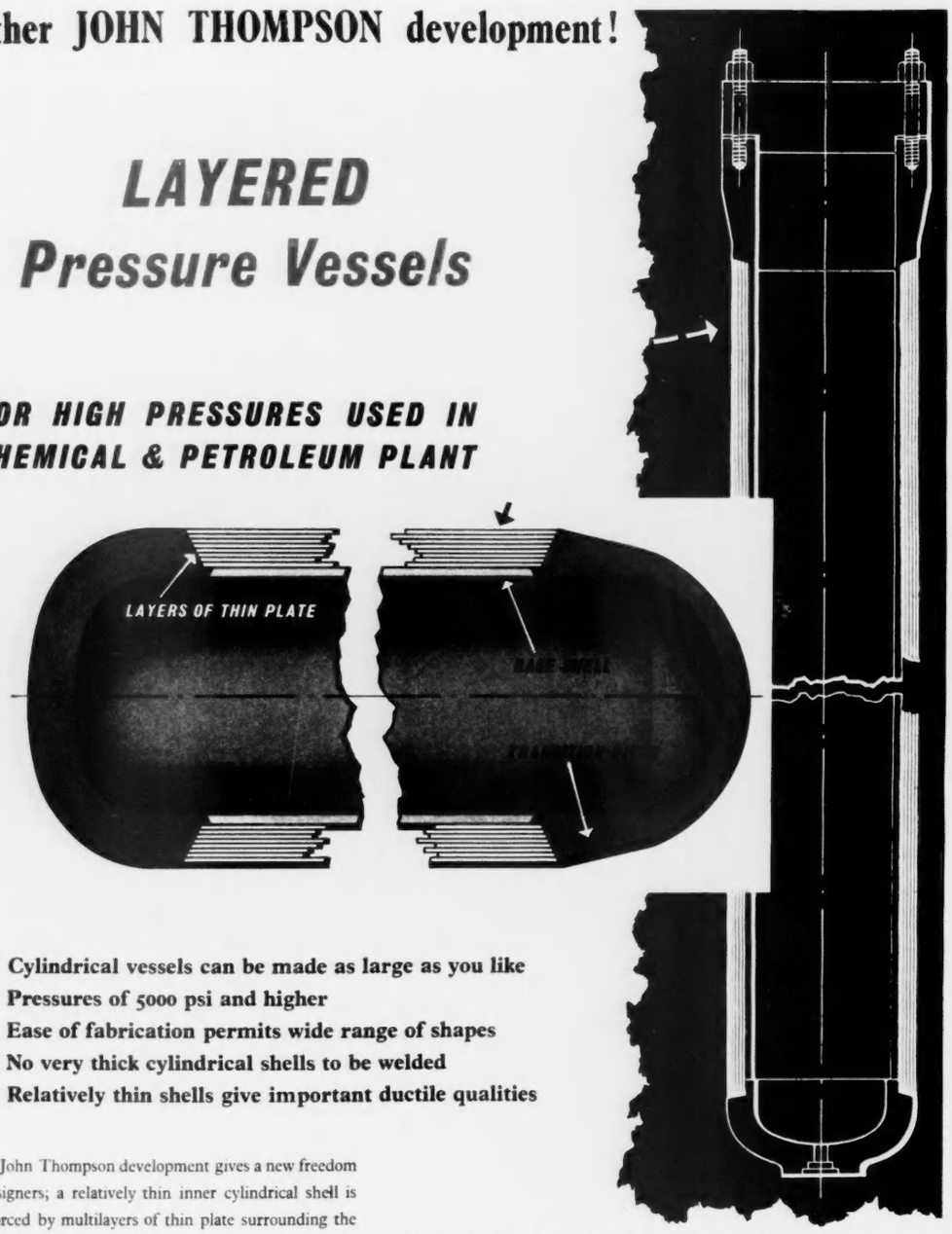

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